SAE Journal

SEPTEMBER 1954

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WHERE IS PRESSURE GREATER?

100 fathoms under the sea

...or inside a car's engine?

When combustion occurs, the pressure within the cylinders of an engine goes as high as 600 lbs. per square inch... actually *twice as high* as the pressure at 100 fathoms below the sea!

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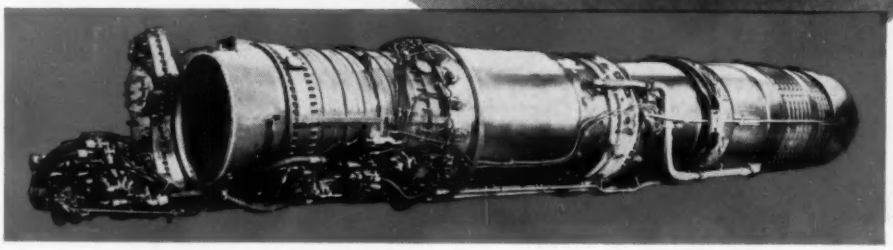

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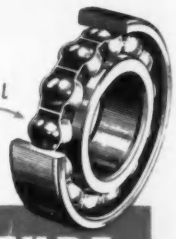

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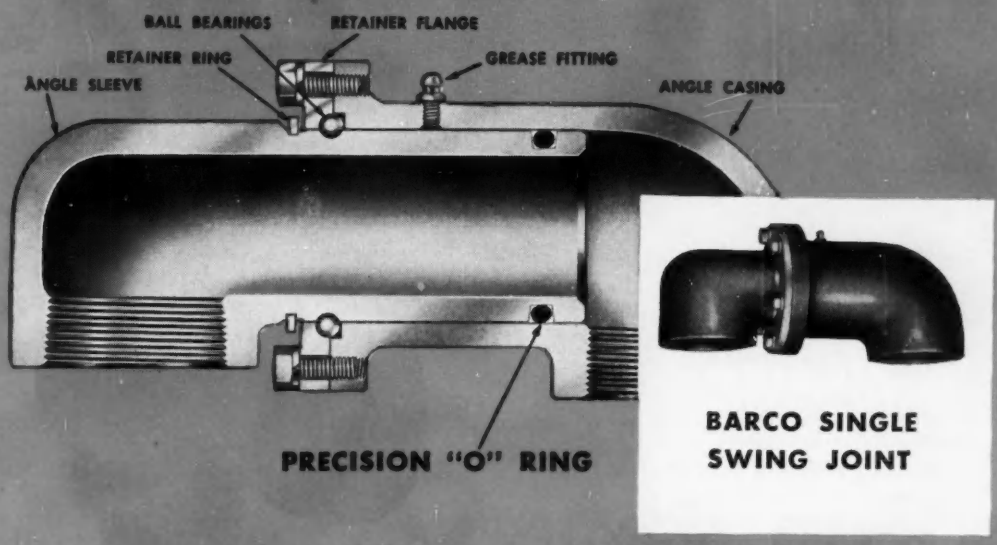

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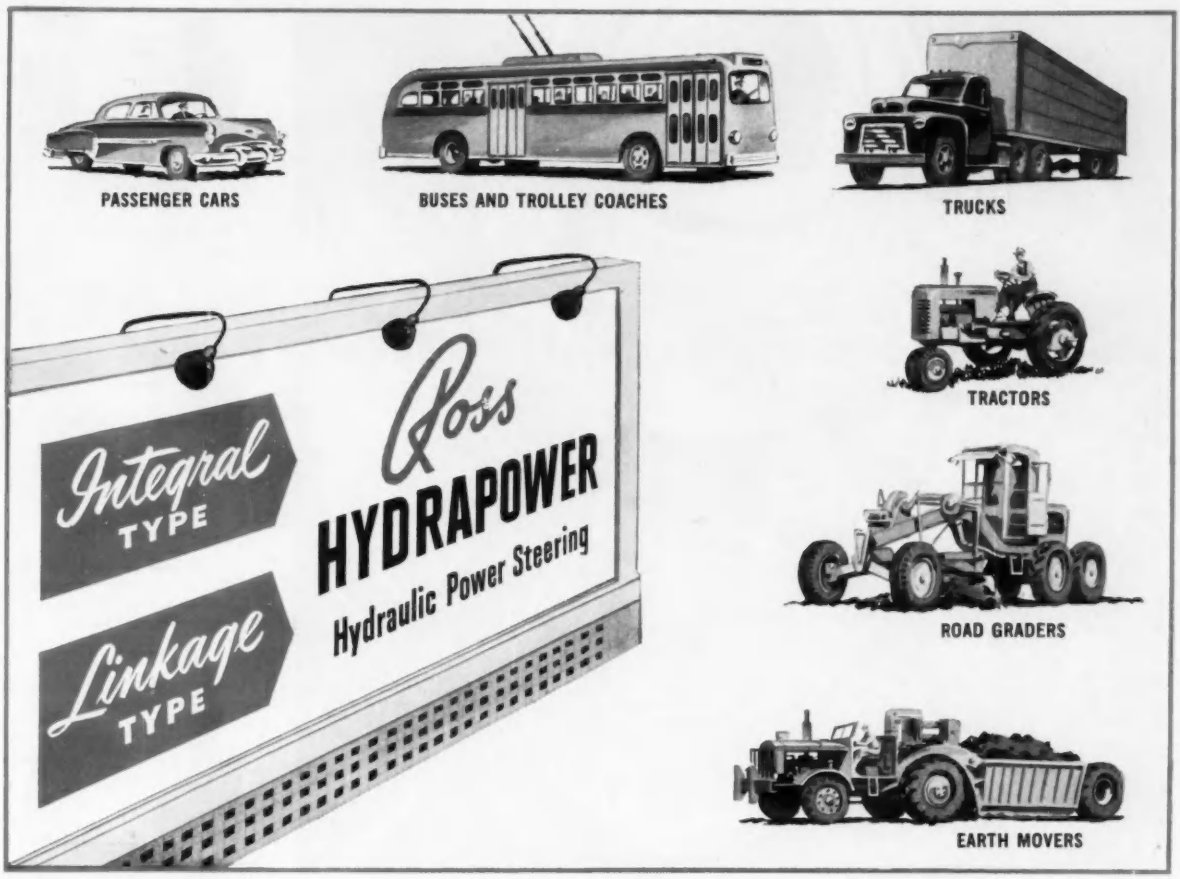

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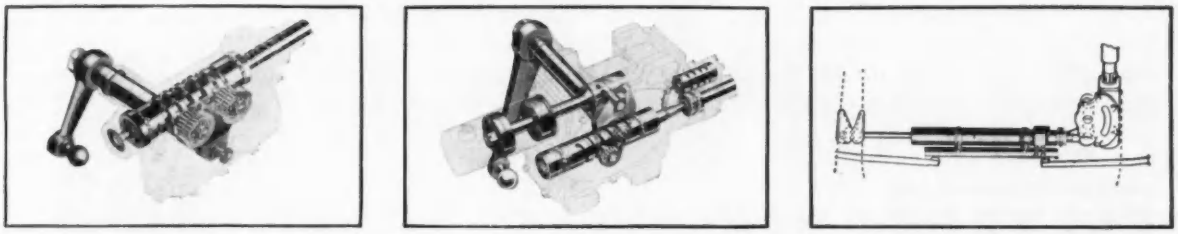
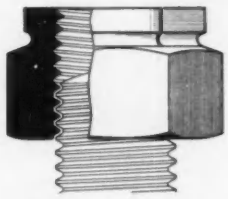
STEERING

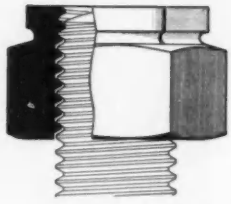


CAM & LEVER MANUAL . . . HYDRAPOWER INTEGERAL . . . HYDRAPOWER LINKAGE

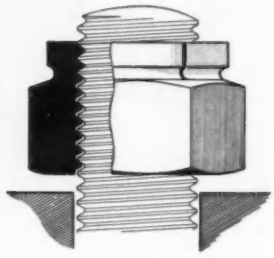
Manufacturers of couplings like these find that FLEXLOC Self-Locking Nuts provide faster assembly and safer, more dependable locking than is afforded by most other methods.



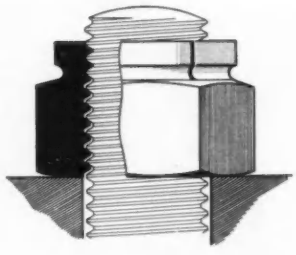
Starting. A FLEXLOC starts like any ordinary nut. Put it on with your fingers. Tighten it with a standard hand or speed wrench.



Beginning to Lock. As the bolt enters the segmented locking section, the section is expanded, and the nut starts to lock.



Fully Locked As a Stop Nut. When 1½ threads of a standard bolt are past the top of the nut, the FLEXLOC is fully locked. A FLEXLOC does not have to seat to lock.



Fully Locked As a Seated Nut. When it is used as a lock or stop nut, the locking threads of the FLEXLOC press inward against the bolt, lifting the nut upward and causing the remaining threads to bear against the lower surface of the bolt threads. Vibration will not loosen a FLEXLOC, yet there is no galling of threads.

Here's why more and more original equipment manufacturers specify FLEXLOCs

Whether it's on power transmission couplings or on access doors of helicopters, more and more FLEXLOC Self-Locking Nuts are being used to insure positive fastening of assemblies.

There are many reasons for this. FLEXLOCs reduce production costs. They are easy to install. They are one piece, all metal—nothing to assemble, come apart, lose or forget. They eliminate complicated, time-consuming methods of locking bolts and studs. They stay put—once their locking threads are fully engaged, they won't work loose. They are easy to get—SPS can make prompt delivery of FLEXLOCs in any quantity, and in a wide range of sizes, through a national organization of industrial distributors. Write for literature and samples. STANDARD PRESSED STEEL Co., Jenkintown 55, Pa.

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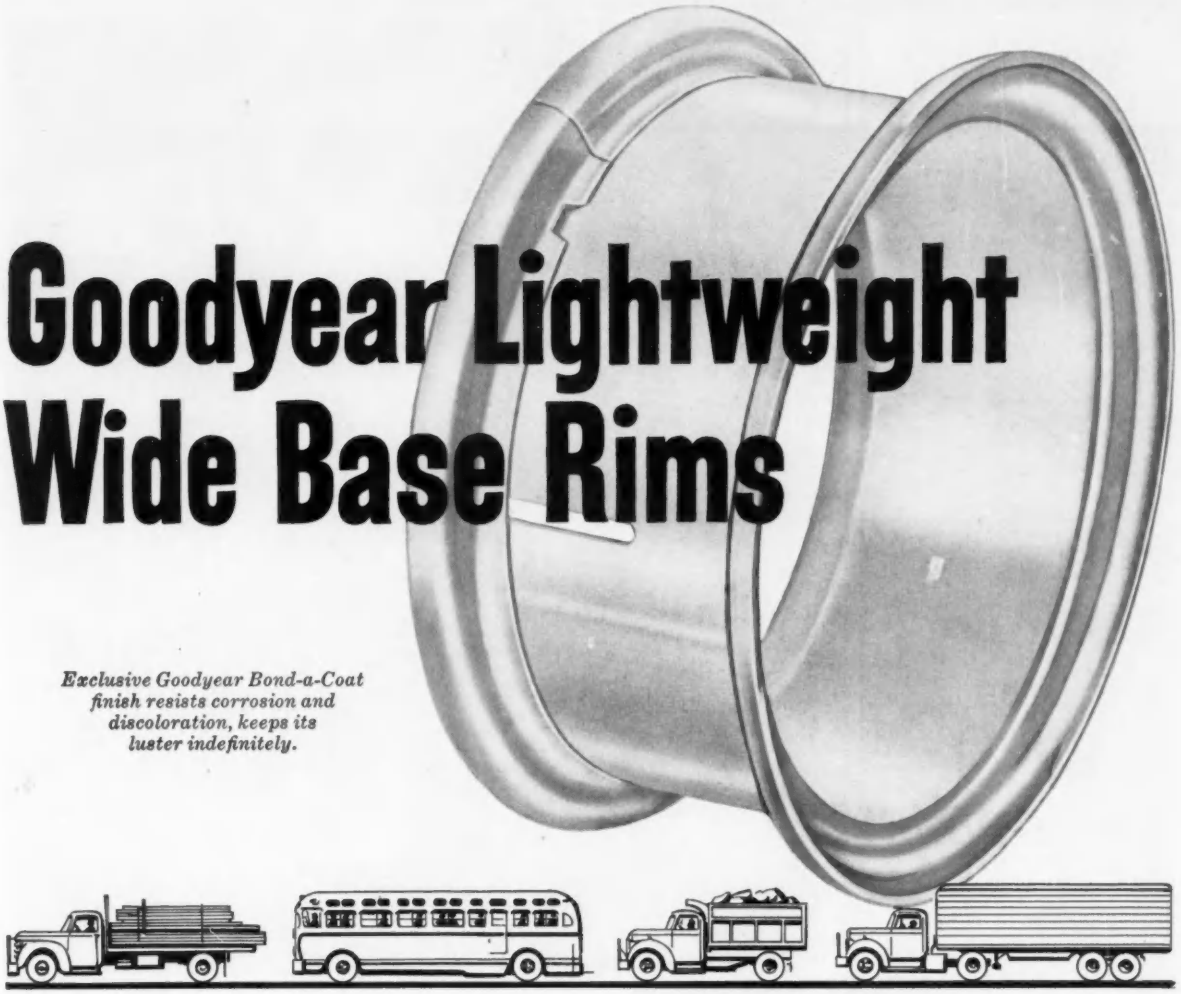

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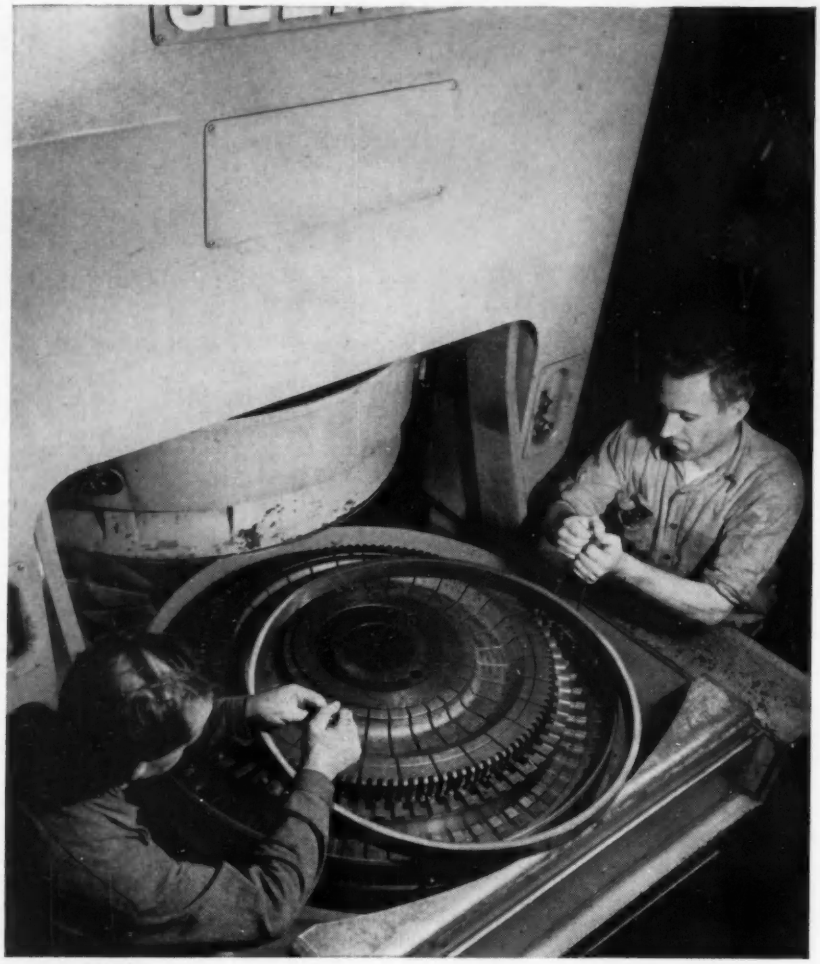
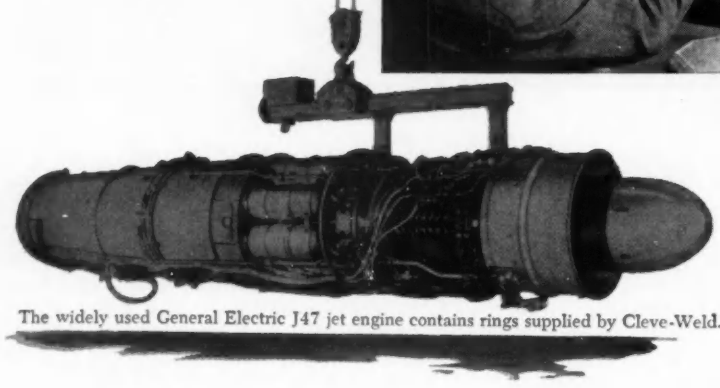
MORE TONS ARE CARRIED ON GOODYEAR RIMS THAN ON ANY OTHER KIND

Rings for jet engines ...by Cleve-Weld



The largest quench press of its kind prevents distortion during heat-treating and assures uniform structure of Cleve-Weld jet rings.



The widely used General Electric J47 jet engine contains rings supplied by Cleve-Weld.

An ever-increasing number of stainless steel and high-temperature alloy rings for America's jet engines are being produced by the Cleve-Weld Process. Use of Air Force-approved welding, heat-treating and machining equipment permits these rings to meet exacting physical and metallurgical tolerances.

That Cleve-Weld should be playing an important part in the production of welded rings for turbo-jet engines is not surprising. Certainly its nearly half-a-century of experience in the metallurgy and techniques of shaping and welding circular steel parts for many purposes uniquely fit it for such a role!

A 28-page illustrated brochure has just been prepared to provide prospective customers with a comprehensive picture of the engineering and production facilities which are here to serve their needs. All design, production and procurement executives concerned with jet engines are invited to send for a free copy. Write THE CLEVELAND WELDING COMPANY, West 117th Street & Berea Road, Cleveland 7, Ohio. (A subsidiary of American Machine & Foundry Company, New York)

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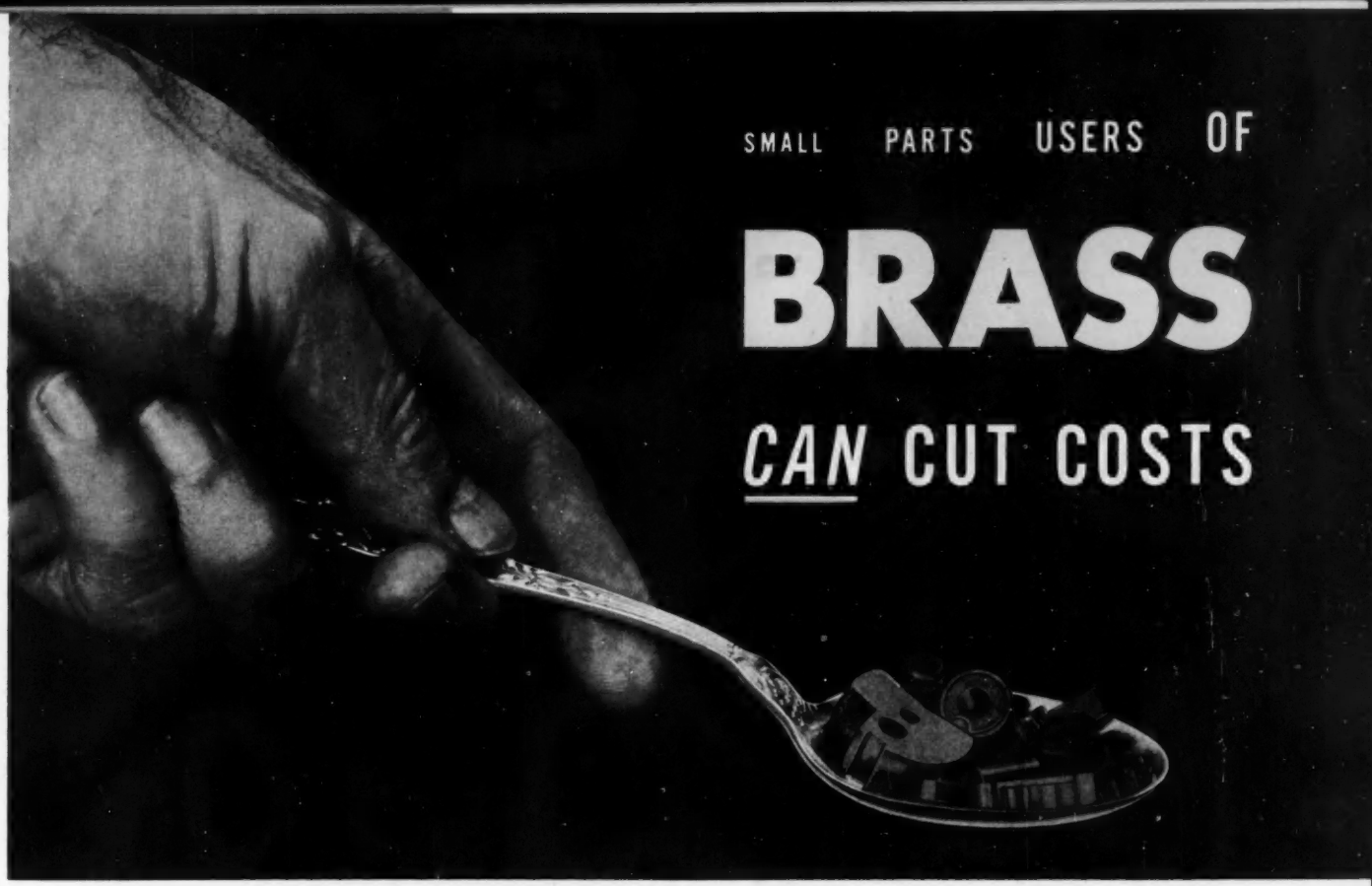

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For the Sake of Argument

Tomorrow's "Us" . . .

By Norman G. Shidle

Tomorrow's *us* is ours to fashion—by what we make our own today.

From all the ideas, events, people, and reading life brings us each day, to what are we listening most? What persons, what concepts, what ideas are having the most influence on us?

We like to think that we analyze, reason about, and make our own this idea or that point of view. We like to feel we choose concepts from all those which pelt our minds . . . choose, and then envelop them. How often, though, has the impinging concept enveloped *us*, made us *its* own?

When we have made a philosophy our own, we can't help living by it. When it's really ours, it is an integrated part of us—of our sense of being. No longer is it something external, something we reach for and "apply" to our problems or our life. When a concept has been made ours, we no longer use it. It uses us. That's why we can't help living by it, not just with it.

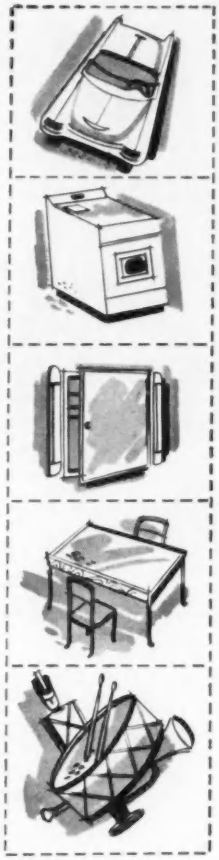
It's the integrated mass of accumulated concepts, which each has made his own, in other words, which constitutes *his* sense of being. When we select from the mass of concepts our own candidates for possible integration, we move toward being what we want to be. When we let the impinging concepts envelop us, we can't be sure just where we are going.

People we invite to come to live with us inevitably modify our way of life as we do theirs. From integration of these modifications a new, whole, household results. The new household is a melding, rather than a welding, of the characteristics of the new people and the old.

So it is likely to be with our individual sense of being. It tends to consist at any given time of what we were yesterday, integrated with what we have made our own today. . . . and today is tomorrow's yesterday.

Ralph W. Sockman, speaking of Lord Byron recently, gave a good hint on what to avoid in trying to make selections. Lord Byron, he said, "took what he wanted until he no longer wanted what he took." Maybe that's the same as saying we had best take what we need rather than merely what we want.

LESSON IN STAYING PUT



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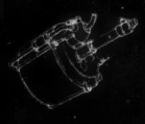

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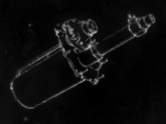
With over four million in use, the Bendix Hydrovac is by all odds the world's most widely used power brake for commercial vehicles. This overwhelming preference for Hydrovac is a result of sound engineering design, exceptional performance, low original cost and minimum service upkeep.



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Prospects are easier to sell and owners are better satisfied with cars equipped with Bendix power steering and braking.

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For truck manufacturers and operators, Bendix Hydrovac and Air-Pak have long been overwhelming favorites in the field of power braking for commercial vehicles.

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The S's* Have It

Small Size—A Must for the European Pocketbook

Table 1—Specifications of European Cars

Make and Model	Maximum bhp	Wheelbase	Track	Dry Weight lb
	Czechoslovakia			
Minor II	20	91	45	1480
Skoda	32	98	49	1960
Tatra	56	106	51	2680
	United Kingdom			
Austin A.30	30	79½	45	1460
Austin A.40	40	92½	49½	2160
Austin A.70	68	99	56	2740
Ford Popular	24	94	45	1670
Ford Prefect	36	87	48	1500
Ford Consul	47	100	50	2450
Ford Zephyr	68	104	50	2600
Hillman Minx	37.5	93	51	2000
Morris Minor	30	86	50½	1750
Morris Oxford	41	97	53	2200
Standard Vanguard	68	97½	50½	2800
Standard Eight	26	84	48	1450
Vauxhall Wyvern	40	103	54½	2200
Vauxhall Velox	64	103	54½	2340
	France			
Citroen 2 c.v.	9	93½	49½	1100
Citroen 11 c.v.	56	114	53	2350
Ford Vedette	60	106	54	2580
Peugeot 203	42	100	52	2000
Renault 4 c.v.	19	82½	47	1180
Renault Fregate	60	110	55	2420
Simca	45	96	48½	2080
	Germany			
D.K.W.	23	88½	49	1750
Ford Taunus	38	98	48	1875
Mercedes-Benz 170	52	112	53	2600
Mercedes-Benz 180	52	104	57	2300
Opel Olympia	45	95	49	2000
Opel Kapitan	65	106	53	2660
Volkswagen	25	94½	51	1540
	Italy			
Fiat 500 B	16	79	44	1200
Fiat 1100	36	92	48	1750
Fiat 1400	44	104½	51½	2500
	Sweden			
Saab	25	97	46	1680
Volvo	43	104½	51	2130
	Average European Car			
	42.0	95	50	2030

THE European car has been small and light for a long time, and no doubt it will stay that way for the next 10 years. There are many good reasons.

For one thing, very few Europeans can afford even a small car, much less a large one. In fact, 90 European cars out of 100 are purchased by business firms—and used for both business and pleasure.

For another, the burden of arms is very heavy in some European countries, notably the United Kingdom. The tax money that went into the postwar development of two British jet engines, for example, would have paid for ⅛ of all the cars put on the British market since the war. And one 100-hr test of a jet engine consumes enough fuel to keep 3% of all British cars running for a month.

Trade restrictions between the countries of Western Europe hurt, too.

Thus, not only are European cars smaller than U. S. ones, fewer of them are produced each year. In 1953, for example, Western European countries produced a total of only 1,418,000 private cars (United Kingdom—570,000; France—360,000; Germany 355,000; Italy—133,000). And probably only a little over 1,000,000 of these were actually sold in Western Europe.

Surprisingly enough, this relatively small number of vehicles (by U. S. standards) includes over 50 major makes and about 120 different models. Weights range from 1100 to 5900 lb, engine outputs from 9 to 210 bhp, maximum road speeds from 45 to 145 mph, fuel consumptions from 10 to 40 mpg, and prices from $1000 to $17,000.

At first sight, these variations might seem to defy an attempt to generalize on European design. However, there is reasonable uniformity between 90% of the cars sold by 14 European car manufacturers.

Reduced to the essentials of engine output, wheel-

Table 2—Comparison of European Cars with Chevrolet

	European			
	Small	Large	Average	Chevrolet
Hp	19	68	42	105
Weight (Lb)	1180	2800	2030	3400
Wheelbase (In.)	79½	112	95	115
Track (In.)	45	56	50	58
Platform Area (Sq Ft)	25	43½	33	47

With European Car Design

*Small Size
*Single-unit Structure
*Simple Shape

Laurence Pomeroy, Technical Editor, The Motor

Based on paper, "The Size, Structure, and Shape of European Automobiles," presented at SAE National Passenger-Car, Body, and Materials Meeting, Detroit, March 2, 1954. Complete paper will be published in full in 1955 SAE Transactions.

base, track, and weight, 90% of the million cars purchased by average Europeans last year had specifications as shown in Table 1.

Going one step further, Table 2 compares the power and dimensions of small, large, and average European cars with those of a typical American car, the Chevrolet. (In this comparison, the 2 c.v. Citreon is excluded as it is a special-purpose vehicle, although an extremely popular one.)

Comparing the average European vehicle with the Chevrolet, we find that the wheelbase ratio is 1 to 1.2 and the track ratio is 1 to 1.16. The weight ratio is 1 to 1.5, the power ratio 1 to 2.5. Finally, and perhaps most important, the platform area (product of wheelbase and track) of the average European car is 30% less than that of the Chevrolet.

It would thus seem that if the Chevrolet seats five or six, then the smallest European cars with only half the platform area would be 3-seaters. But European designers contrive by various means to accommodate four persons within a very restricted space. (See Fig. 1.) Here are a few of the things they do to accomplish this:

1. About 4 in. is gained lengthwise by placing the foot pedals 4 in. nearer to the front wheel center. A further 1 or 2 in. is often saved by modifying the pedal mounting and reducing pedal travel.

2. Floor level on many cars is placed at hub center, or even a little below.

3. The engine is placed behind or ahead of the axle centers in some cars. Hence, it does not extend lengthwise into useful passenger-carrying area.

As a result of these and other design devices, there is available for seating on European cars, a **length** equal to or slightly more than the wheelbase, a **width** equal to or slightly more than the track, and a **height** equal to that available in larger cars. (Overall height of the vehicle, however, is frequently less than 60 in.)

Single-Unit Structure—It Helps to Keep Cars Light

Large-scale European manufacturers do not depart greatly in materials or in methods of fabrication from the welded all-steel body pioneered by Hudson and Budd nearly 30 years ago. In fact, the only European cars made with separate frames are continuations of basic prewar types.

Combined body and chassis construction has made possible weight savings of as much as 100 lb on small cars (about 5% of the total). Simultaneously, it has permitted torsional stiffness to be doubled.

By eliminating the frame, the complications introduced by side rails at an inconvenient width have disappeared. However, both the floor and the roof are severely stressed. There is indeed a danger of frameless cars becoming two very deeply boxed structures at each end of the car with a somewhat tenuous support between them.

This is especially true since it is absolutely neces-

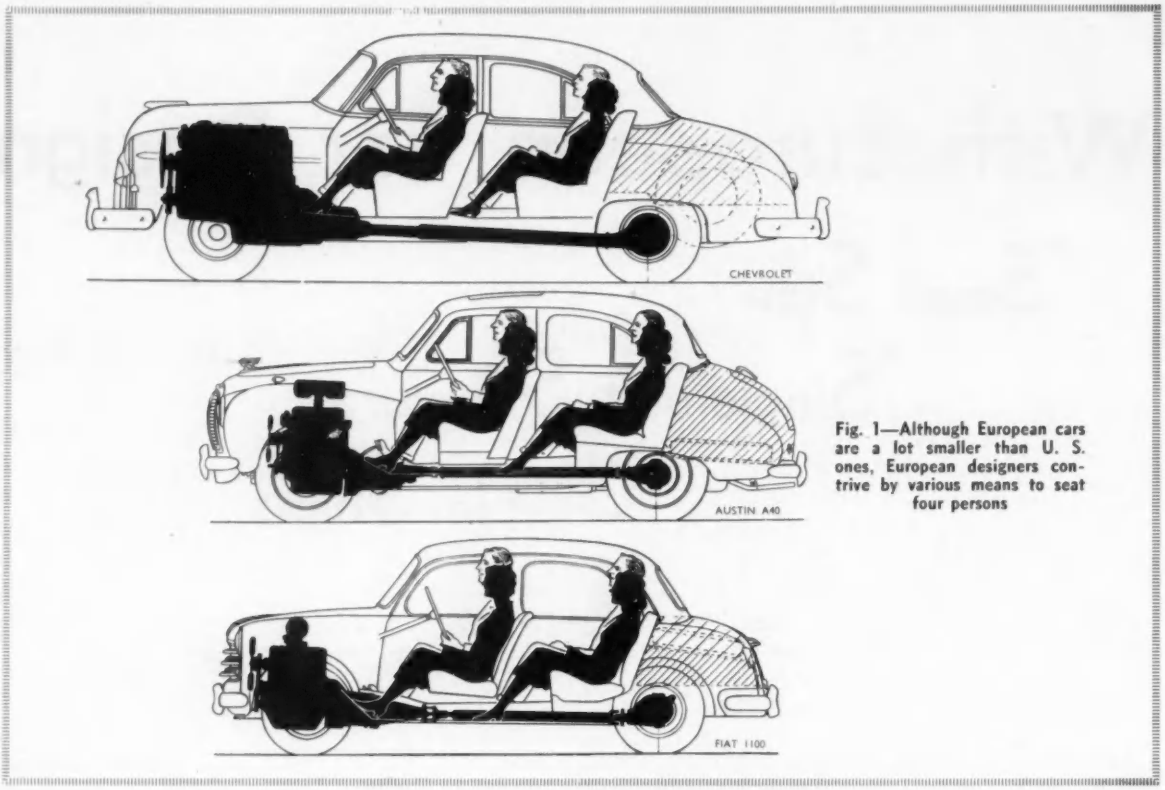


Fig. 1—Although European cars are a lot smaller than U. S. ones, European designers contrive by various means to seat four persons

sary to provide four doors except on the cheapest cars. Here's why.

The intending occupant of the back seat of a European car is confronted with a gap between the leading edge of the back seat and the back of the front seat that is normally not more than 9 in. Entrance is further complicated by the comparatively low roofline. A 6-ft American has to stoop but 6 in. to enter a Chevrolet, but the Englishman of 5 ft 10 in. must bow his head a foot before he can enter a Morris Minor. Under these circumstances, it is essential to enter the gap at right angles if an unseemly scramble for space is not to be witnessed.

Unfortunately, four doors considerably weaken the unitary structure. And for a given standard of stiffness, the 4-door body must be paid for by greater weight.

Be that as it may, European cars would be a great deal heavier than they are if they had separate chassis frames.

It may be argued that the small size of the European car is favorable to the designer seeking to construct a stiff lightweight structure. On the other hand, material thicknesses cannot be scaled down in proportion to car size and some items (glass, wheels, instruments, steering wheels, door hinges, handles, and so forth) represent a virtually constant weight irrespective of car size. Therefore, one would expect European cars to be slightly heavier than American types in proportion to their size.

It is somewhat difficult to draw definite conclusions on this matter. Almost any criterion upon which the judgment is based will be unfair to one class of car or another.

The author has taken as his standard the greatest cubic content potentially available for carrying passengers. To get an approximate idea of this capacity, the frontal area of various cars has been multiplied by the distance between the wheel centers. This gives a typical American car, such as the Chevrolet, 302 potentially useful cubic feet, more than double the figure obtained on the smallest European cars.

On this basis, the Chevrolet weighs 112 lb per available cu ft—a figure that is 3% greater than the average for 12 representative European cars. The latter, however, vary considerably among themselves, the rear-engined 45-cu in. Renault weighing only 84.5 lb/cu ft, whereas the front-engined 122-cu in. model from the same factory weighs 99 lb/cu ft. Similarly, the 65-cu in. Fiat weighs 103 lb/cu ft and the 85-cu in. model weighs 123 lb/cu ft.

In short, European designers achieve a reduction in specific weight in comparison with considerably larger cars, but the differences between cars built on opposite sides of the Atlantic are not great.

Unitary bodies do have one serious drawback, however. Their highly stressed panels are bad offenders as magnifiers of high frequency noise. The problem has been magnified by the position of the front wheels which causes road noise to be fed directly into the scuttle and driving compartment. A leading British designer once remarked that if you took the engine and transmission out of his car and

let it roll downhill over a rough road, you still would not be able to hear yourself speak.

Some companies have given much thought to suppressing road noise. In the Standard 8 and the Mercedes-Benz 180 cars, an attempt has been made to isolate both engine and road noise by using rubber mountings. Vauxhall has been notably successful in quieting its cars by the strategic disposition of sound-damping felts and sprayed-on materials.

To sum up, combining the body and frame into a single unit offers important advantages in stiffness, strength, and weight reduction. It is also an arrangement particularly well suited for the modern small car where front suspension elements can be located immediately upon the scuttle and where width between doors is greater than the wheel track. On the debit side, single-unit construction involves minor penalties with respect to repairing damage and lowering noise level.

Simple Shape—Low on Frills and Repair Bills

The shape of most European cars is practical, easy to keep clean, and simple to repair. (See Fig. 2.) Some may consider it excessively box-like in appearance, however. The more rounded lines of the Hillman Minx are one alternate.

The small size of European cars makes any effort at ornamentation a somewhat perilous exercise. That's because there is insufficient mass of motor car to carry any elaboration of chromium-plated strips, panels, and the like. Hence, styling is considered more in relation to the basic shape than to any applied features.

The front air intake, which the U. S. stylist has built up as a dominant feature, is comparatively unobstrusive on European cars. It is non-existent on the rear-engined Renault and Volkswagen. (The former does, however, have some slightly suggestive horizontal chromium strips mounted on the nose of the car.) On the new Standard 8 with its conventional engine position, the air entry is a simple scoop of diminishing cross-section that is innocent of chromium plate. The latest Ford and Fiat cars also show a marked tendency to simplify this particular aspect of external appearance.

For practical reasons, one might expect the squared-up style eventually to be embraced by most European manufacturers. It does, however, seem to be an inherently poor shape from an aerodynamic point of view.

And drag is important on really small cars. Whereas it is rarely possible to drive a 100-mph car for long distances at full speed, it is comparatively easy to hold a 60-mph car at its terminal velocity. As specific fuel consumption tends to rise at full throttle and maximum engine rpm, it follows that the overall mpg on small cars can be disappointing when they are driven fast.

Much of the drag on the modern motor car would be termed "parasitical" by an aircraft engineer. It rises from protuberances (door handles, inset of windows), from unavoidable losses through the radiator core, and from wind being trapped in the wheel arches. Although there are no accurate figures upon which to base a dogmatic statement, it seems likely that these losses are a higher proportion of the total on small European cars than they are on larger American cars.

Therefore, to retain equality on a basis of road speed in relation to hp/sq ft of frontal area, the European designer must make strenuous efforts to reduce drag wherever possible.

This has been achieved more by attention to detail than by use of radical aerodynamic form. The Fiat 1100 is a particularly interesting example of this; for although it is of the square outline school, it has a road speed substantially in excess of the calculated maximum. Here are a few reasons why. The wheels are set out almost to the full width of the body. Wheel arches are of minimum size. Windows are placed as nearly flush as possible to the outer side of the car.

The most advanced European small car from the aerodynamic standpoint is the recently introduced Dyna Panhard 54. Since this is a front-wheel-drive model, it has been possible to provide a floor which serves as a smooth under tray. Great care has been taken to suppress protuberances and to give a well shaped envelope. The result is a road speed of 80 mph with only 1.92 hp/sq ft—a gain of 10% over the theoretically computed speed. This is equivalent to a drag reduction of 33-1/3% compared with a typical U. S. car.

Now, what about the future? European cars can be expected to continue using a unitary body and chassis. However, it may be stiffened up to 25% and simultaneously lightened 10% as greater knowledge is accumulated of the stress pattern over the shell. Noise suppression will certainly be improved, at least in England and Germany. But it is likely that the weight penalty arising therefrom will offset the gains achieved by the stress men. There probably will be little change in curb weight or serious changes in overall dimensions.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Fig. 2—The 35-hp Ford Taunus has set the pattern for modern European popular car styling

Aircraft Noise Stops

FOR a long time, the aircraft noise problem grew almost as uninhibitedly as Topsy. But not any more. Its parents—the members of the aircraft industry—have begun to crack down on this wayward "child." To keep down complaints of people living around airports and ground test facilities, the various aircraft industry members are focusing their efforts toward:

1. Reducing noise intensity at the source.

2. Increasing the distance between the noise source and the receiver.

One engine manufacturer, for example, points out that jet transports could be designed to use lower specific thrust during take-off. Since noise power level of jets is roughly proportional to the eighth power of the specific thrust, it is felt that this would be a natural solution to the airport noise problem. Another powerplant builder has found that turboprop propeller noise can be substantially reduced by using low rpm, many-bladed propellers (but not without incurring weight penalties).

More attention is also being given to the suppression of noise made by ground test facilities. One aircraft manufacturer has come up with a device for B-52 engine run-up tests that has so far eliminated all noise complaints. This suppressor consists of steel-shell mufflers which completely enclose each engine pod and massive concrete tunnels that terminate in a vertical exhaust stack.

Air transport operators are getting on the noise-

This article is based on the following seven papers presented at the Symposium on Aircraft Noise held at the SAE National Aeronautic Meeting, April 14, 1954:

Basic Facts About Noise as Related to Aviation

—A. C. Pietrasanta,
Bolt, Beranek and Newman, Inc.

—R. H. Bolt,
Acoustics Laboratory, MIT

Why Do Airplanes Make Noise?

—A. A. Regier,
National Advisory Committee for Aeronautics

Acoustic Design and Performance of Turbojet Test Facilities

—R. O. Fehr and B. E. Crocker,
General Electric Co.

An Airplane Manufacturer's Progress with Noise Suppression Devices

—H. W. Withington and Robert Fogle,
Boeing Airplane Co.

Jet Noise

—J. M. Tyler and E. C. Perry,
Pratt and Whitney Aircraft Division, United Aircraft Corp.

Propeller Noise Control in Turboprop Engine Installations

—Joern Schmey and R. M. Guerke,
Propeller Division, Curtiss-Wright Corp.

The Aircraft Noise Problem in Airport Vicinities

—Admiral C. E. Rosendahl,
National Air Transport Coordinating Committee

These papers are available in full in multilithographed form from SAE Special Publications Department as SP-121, Aircraft Noise Symposium. Price: $2.25 to members, $4 to nonmembers. Copies of any of the papers can be obtained by members for 35¢ each and by nonmembers for 60¢ each.

Growing Like Topsy

suppression bandwagon too. Much has been accomplished through adoption of certain airport procedural measures that increase the distance between aircraft taking off and landing and airport neighbors. As much as possible planes are being routed out of and into airports on runways that permit flying over water, open areas, and least congested areas. Steeper climb-out gradients, whereby planes get to 1200 ft altitude sooner, are also being used.

How to Describe Noise

Before delving into what's being done about aircraft noise, it might be well first to establish just what noise is. For one man's music may be another man's noise.

A noise source can be described completely by specifying its total acoustic power and the distribution of this power with respect to frequency and space.

Fig. 1 shows the acoustic power output of several familiar kinds of noise sources. The total power radiated by most aviation noise sources is, in general, independent of the noise source environment. In other words, whether a jet engine or a propeller is operated in an airframe, in a test cell, or on a test stand in an open field makes little difference with regard to its total acoustic power output. Consequently, the only true comparison of aviation noise sources is the total acoustic power output of each.

A knowledge of the frequency distribution of noise is also essential. Frequency distribution determines the character or quality of a noise. The characteristic roar of a jet-engine afterburner, for instance, indicates that the frequency spectrum of the noise has a maximum in the low frequency region. The hissing noise of a compressed air jet or the whine of an idling turbojet engine, on the other hand, is mainly high frequency in nature.

As for space distribution, noise sources generally do not radiate sound uniformly in all directions, but rather in certain preferential directions. Fig. 2 illustrates this. It shows a typical directional noise pattern for a single-engine jet aircraft operating at military power. Let us suppose that two men, each armed with a sound-level meter, ventured into the noise field and took readings at points X and Y. Their readings would have been 108 decibels at X and 128 decibels at Y—a difference of 20 decibels! This clearly demonstrates that angular location, as well as distance from the noise source, must be taken into consideration.

In general, the noise produced by aircraft noise sources can be related to the operating characteristics of these sources. For instance, it has been

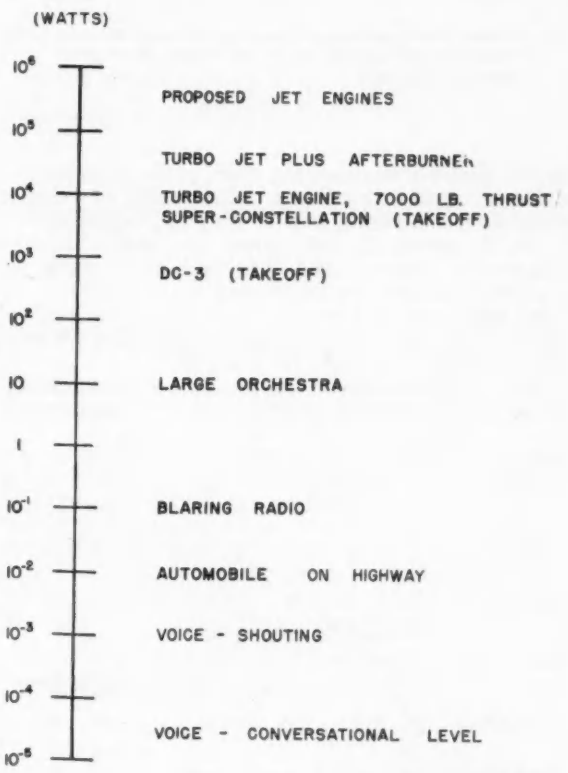


Fig. 1—This shows the acoustic power output of several familiar kinds of noise sources

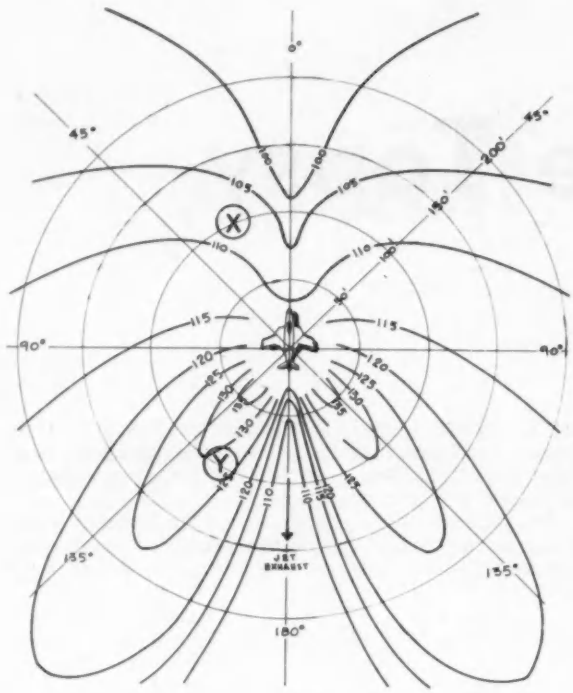


Fig. 2—Noise sources generally do not radiate sound uniformly in all directions, as illustrated by the jet aircraft shown above

found that an engineering description of propeller noise, adequate to cover a wide range of normal operating conditions, can be given in terms of (1) blade tip speed, (2) horsepower per blade, and (3) number of blades. And the total noise power of turbojet engines can be related empirically to the total mass flow of air and fuel through the engine, the jet exit velocity, the temperature at the jet exit, and the diameter of the jet tail pipe.

Such relationships as these can be extrapolated, allowing one to estimate the noise characteristics of aircraft sources from their operating characteristics. This is especially important in the design of new engine test facilities or the evaluation of an airport noise problem involving future aircraft.

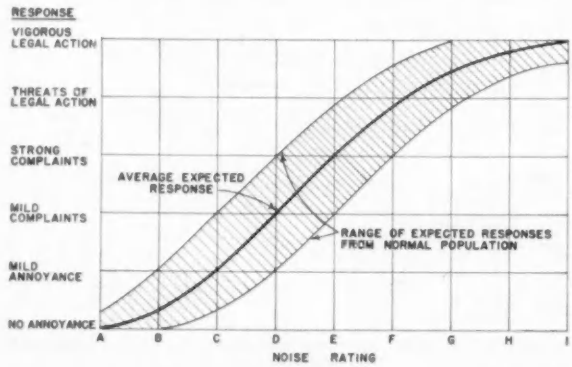


Fig. 3—This shows the statistical range of expected neighborhood reaction to intruding aircraft noise

Level of Noise That Will Be Tolerated

Just how disturbing an aircraft noise will be to people living in residential areas cannot, however, be predicted from a physical description of the noise reaching these individuals. There are at least seven factors that will have a bearing on this:

1. **Spectrum character**—A noise spectrum that contains audible pure-tone or single-frequency components is usually more annoying than a spectrum that is reasonably continuous in frequency.

2. **Peak factor**—A noise that is reasonably continuous (a few seconds, at least) is less annoying than an impulsive type of noise.

3. **Repetitive character**—A noise that lasts for 20 sec, but is repeated every minute, is more annoying than the same noise repeated twice a day.

4. **Level of background noise**—Tolerance of intruding noise is markedly influenced by the average background noise in the community.

5. **Time of day**—Intruding noise is usually more tolerable in the daytime than during the sleeping hours of nighttime. Also, at night, background noise levels from traffic and other sources are usually lower; hence, an intruding noise is more noticeable.

6. **Adjustment to exposure**—Residents can become conditioned to intruding noise after repeated exposures.

7. **Intruding noise levels**—The actual sound-pressure levels as a function of frequency of the intruding noise are, of course, important variables in the overall problem of estimating neighborhood reaction.

From proper weighting of each of these factors, one can determine a noise rating. This noise rating enables one to estimate the statistical range of neighborhood reaction to intruding noise. An empirical relationship has been derived, which has been substantiated by a great number of case histories, that relates the noise rating to the average expected response. This relationship is shown graphically in Fig. 3. Since all residents of a particular community do not react alike to intruding noise, a range of expected response from a normal population must be specified.

Noise Depends on Jet Exit Velocity

Now just what causes jet aircraft to make noise? A lot of research work has been done to find out . . . and a lot more remains to be done. But experimental work to date appears to confirm Lighthill's theory—that jet noise generation varies as the eighth power of the jet exit velocity.

Proof that jet noise is largely a function of velocity is given by the fact that, for a given thrust, a large turbojet engine is approximately 10 db quieter than a smaller one. Why? Because at a given

thrust the air flow of the larger engine is greater than that of the smaller engine; hence, the jet velocity is correspondingly less.

Velocity Reducers Not Too Promising

This strong dependence of jet noise on velocity has led investigators to explore various velocity-reducing devices. Some of these devices are shown in Fig. 4. The oversized pipe that enclosed the jet mixing zone generally aggravated noise because of pipe resonance. The converging-diverging aspirators and the diffuser gave rather indifferent results, except for the overpressured jet. A water-cooled screen, placed in the jet ahead of the region of maximum shear, may have some application to ground run-ups and muffling. Water spray has been tried with some success. However, while such devices show some promise for ground muffling, they do not appear to be feasible for flight muffling.

Other investigators have tried to reduce the noise by putting things into the jet. Some of these devices are shown in Fig. 5.

The point of a screw driver, for example, was found to eliminate the intense screech that develops when a jet is operating at pressure ratios above choking. Slotted cylinders and teeth have also been tried. Full-scale tests made on engines operated at pressures below "choke" showed that teeth reduced considerably the low frequency noise toward the rear of the engines, but increased the high frequency noise in the direction perpendicular to the jets. The net result was a shift in the spectrum without much change in the total sound energy radiated. Air bleeds tested on model jets behaved similar to teeth in relieving the screech condition.

In short, these devices have not proved too promising. But it has been demonstrated that the jet noise spectrum can be changed to a degree. Whether it can ever be changed enough to put it outside the audible range has not been conclusively demonstrated.

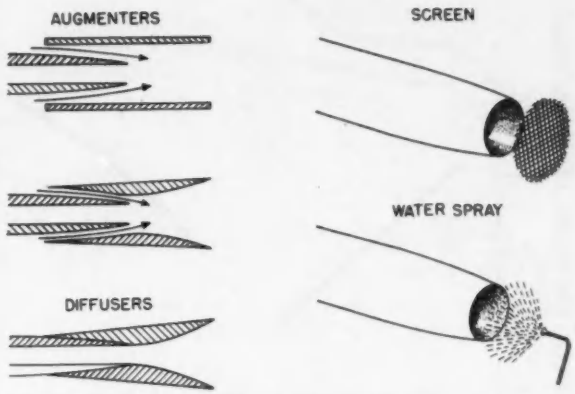


Fig. 4—Various devices have been tried to reduce jet exit velocity, the principal factor determining jet noise

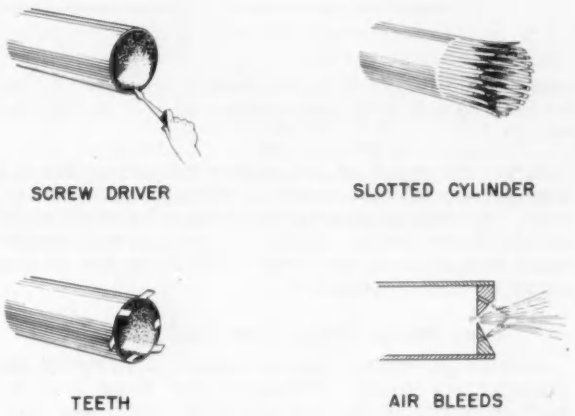


Fig. 5—Some investigators have tried to reduce jet noise by putting things into the jet mixing region

Use Lower Specific Thrust on Take-Offs

When it comes right down to it, should it be necessary to design jet engines with lower noise levels, it can be done, notes one engine manufacturer. It's just a matter of reducing specific thrust (since noise power level of jets is roughly proportional to the eighth power of the specific thrust). The penalty for doing this, however, is poorer specific output.

It is felt, however, that using less than maximum thrust for take-off might prove to be the natural solution to the airport noise problem. Pursuing this idea of noise reduction, the following is of interest:

1. If thrust were maintained at a high level while an airplane was at or near the ground, then reduced as the airplane started its climb, the noise level to which airport neighbors would be exposed would be greatly reduced. That's because there is as much as a 10-db higher noise level a given distance away when a plane is aloft than when it is on the ground at the same distance.

2. Commercial transports are required to demonstrate satisfactory one-engine-out performance. Thus, a 4-engine airplane must perform satisfactorily at ¾ maximum thrust. Now, four jet engines of the size being considered for proposed jet transports produce about 7 db less noise at ¾ thrust than three engines at maximum thrust. Therefore, a commercial transport could climb at an appreciably reduced noise level, using the one-engine-out thrust schedule, by taking the thrust from four engines.

3. As the cruise speeds of transports increase, the cruise thrust required increases faster than the climb-out thrust. This leaves more margin for thrust reduction during climb-out for high-speed jet transports.

4. Using larger engines instead of water injection (putting the weight into the engine instead of into tanks and water) would provide a still greater margin for reduction between maximum thrust and

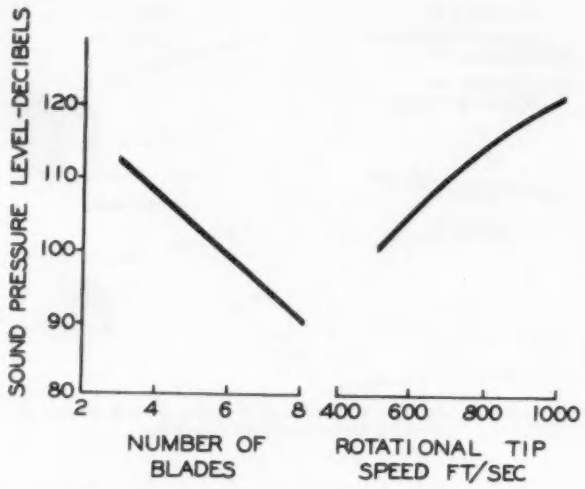


Fig. 6—Propeller rotation noise can be reduced by decreasing tip speed or by increasing the number of blades

climb-out thrust. Thus, the climb operation could be carried out at a lower percentage of maximum thrust.

5. In the event of an engine failure or similar emergency, the full thrust of the engines could be used. Airport neighbors would then be exposed to higher noise levels. But these emergency conditions should be so rare that they should not be the cause of many complaints.

Less Noisy Propellers Add Weight

Just as jet engines can be made less noisy by reducing their specific thrust, so the noise level of turboprop propellers can be cut by using low rpm, many-bladed propellers. However, the penalty in propeller weight that must be paid for a significant noise reduction is severe.

Fig. 6 shows how propeller rotation noise can be reduced with a decrease in tip speed or an increase in blade number. What's more, a combination of these two measures is even more effective in controlling the sound pressure amplitudes.

These expedients could be used, for example, to reduce the propeller rotation noise of a typical 4-engine turboprop transport by 20 db. To achieve the same aerodynamic performance, however, it would be necessary to increase the weight of each propeller by more than 400 lb. And this would mean an almost 1-ton decrease in airplane payload.

In addition, such propellers might seriously affect airplane design. They might result in a requirement for larger landing gear, greater separation of nacelles and fuselage, increased engine mount size and wing structure.

Actually, the airframe design complications and weight penalties that go hand in hand with slow-speed propellers have prevented their application to reciprocating engines in the past. Similarly, little serious consideration is given to the use of "quiet" propellers in turboprops. And it is unlikely that this situation will be altered in the future unless the operators of aircraft are sufficiently concerned about propeller noise to accept the penalties involved.

Steeper Climbs Help

So far, discussion has been confined to ways being explored to reduce the intensity of aircraft noises. This, however, is just one of the approaches being used to reduce complaints about the noise aircraft make in taking off and landing. The other approach—that of increasing the distance between departing and in-coming planes and nearby airport residents—is getting a lot of attention from airline operators.

There's a good reason why. Noise intensity varies inversely as the square of the distance from the source, but sound intensity itself varies approximately logarithmically. For example, if the distance from the source is double, the new intensity will be only ¼ that of the original. If two 100-db sounds are added together, however, the new intensity will be 103 db, not 200. Conversely, if the original sound intensity were halved, the ear would recognize only a 3 db reduction.

Thus, increasing the distance from the source offers greater rewards than decreasing the noise intensity of the source. For that matter, even though source intensity may have to be increased to achieve greater aircraft height, if the height increase is sufficient, the overall sound intensity to the receiver will still be less.

With this in mind, let's take a look at what has been accomplished by the National Air Transport Coordinating Committee for the major civil airports in the N.Y.-N.J. metropolitan area.

In studying the airport noise problem, NATCC found the situation to be more or less like this: Some aircraft were making long, low approaches to terminals, requiring use of considerable power. Some were maintaining relatively low altitudes for extended periods after take-off, intent primarily on quickest possible transit to destinations, with rate-of-climb secondary. Some, to get on course as quickly as possible, were executing low-level turns.

All of these practices were well within Federal regulations, but they were not calculated to improve public relations with people living around airports.

Therefore, the air industry in the N.Y.-N.J. metropolitan area adopted a number of voluntary remedial operational practices. Items:

First, consistent with safety, it was decided to make maximum possible use of preferential runways—runways that would divert operations from residential areas surrounding airports.

Second, a new procedure for climbing to 1200 ft, involving use of steeper climb gradients, was established. On paper, this preferential climb-out procedure offered savings of as much as 2½ to 3½ miles in horizontal travel in attaining 1200 ft altitude. This new procedure is now being implemented in service. And should the results obtained even approximate the paper calculations, a considerable contribution to the noise-abatement problem will have been made.

Third, training flights, where possible, have been

transferred from metropolitan airports to open areas or more suitable airports. This has resulted in substantial relief to airport neighborhoods, since many training flights call for low-level, high-power circling operations. More specifically, the number of landings and take-offs at metropolitan airports have been cut by more than 25,000 per year.

Ground Facilities Get Silencing Too

But the noise made by aircraft coming into and taking off from metropolitan airports isn't the only aircraft noise the aircraft industry is trying to suppress. Attempts are also being made to hush ground test facilities.

Here, the main concern is not to build a bigger and better noise trap. Rather it is to use the least expensive structure that will do a satisfactory job.

Nevertheless, the acoustic treatment of test cells for today's turbojet engines may cost anywhere from $500 to $2000 per decibel attenuation. All these factors enter into determining how much the cost will be:

1. Cell for development work or actual production.
2. New cell or rebuilt reciprocating engine test cell.
3. Horizontal or vertical exhaust and intake ducts.
4. Number of cells to be built simultaneously.
5. Continuous or intermittent operation.
6. Minimum distance to residential neighborhood.
7. Availability of water for cooling purposes.

Here's a good example of what has been accomplished in this area:

Unmuffled running of B-52 engines for periods of more than 5 to 10 min used to bring complaints from people living around the plant—even in daylight hours. A noise suppressor specially designed for this aircraft has, so far, completely eliminated all complaints. (See Fig. 7 for community noise reduction obtained.) It should be reported, however, that engine running time in this suppressor has been limited.

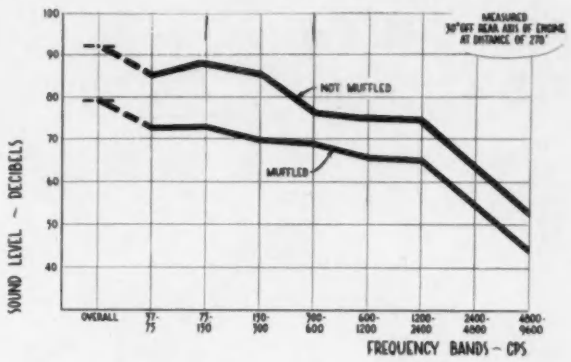


Fig. 7—This shows the community noise reduction obtained with a noise suppressor developed for the B-52 airplane

Essentially, this sound suppressor consists of four separate and distinct mufflers—one for each pod of two engines—grouped to fit the configuration of the B-52 airplane. Each muffler is made up of two units (1) a steel shell that when raised from ground level completely encloses the engine pod, and (2) a massive concrete tunnel lined with sound-absorbing building blocks and terminated with three 90 deg turns and a vertical exhaust stack.

Based on Discussion . . .

Question: Is there any information on the effect of turbojet noise-suppressor devices on thrust?

Answer: NACA's Cleveland laboratory is setting up a dynamometer to acquire such information. Thrust has not been measured during previous tests because there has been no significant noise reduction. Hence, it was assumed that there was no reason for thrust to be affected materially.

Boeing has measured thrust loss in one test operation. It found the loss to be about 20%.

Question: What dictated the length of the B-52 muffler?

Answer: Don't know exactly. It was a quick job and somewhat trial-and-error. The first time it operated exhaust gas came out of the intake end of the muffler instead of the exhaust stack. A model was then made. It worked well, so we followed the model in designing our full-scale muffler. In short, we feel that models should be used in developing noise suppressors.

Question: Does radiation from wing surfaces limit the effectiveness of the B-52 suppressor?

Answer: The front end of the suppressor is affected by wing radiation. The front end is, in effect, not a suppressor but a microphone. The rear end of the suppressor is unaffected. The device as a whole is effective in the direction required.

Question: Would any aircraft manufacturers care to comment on the 400-lb weight increase per propeller cited by Mr. Schmey as the penalty for achieving a 20-db noise reduction?

Answer: Any aircraft manufacturer would be willing to add 400 lb per propeller to reduce noise. However, it is believed that other design requirements would increase aircraft weight much more than this.

Richard M. Carlson, Chief Structures Engineer, and

F. David Schnebly, Structures Engineer, Hiller Helicopters, Inc.

Excerpts from paper "Service and Testing Observations of Fatigue Failures in Helicopter Components," presented at SAE Annual Meeting, Detroit, Jan. 14, 1954. This paper will be printed in full in SAE Transactions. It is also available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

Fatigue Failure Preys on

PROGRESSIVE or fatigue type failure has plagued mechanical devices for a long time. The helicopter particularly suffers severely from this phenomenon.

Shown here are just a few of the 169 failures accumulated during four years and 58,000 hr of flight time on the Hiller 360 helicopter.

The implications of these examples reach beyond the helicopter. They alert engineers of other automotive equipment to the dangers that lurk behind fatigue-inviting designs. There's a lesson here too for manufacturing and maintenance men.

Design Errors

. . . it's usually the unexpected

Case 1: A Bending Moment of Moment

A PART failure due to detail design is shown in Fig. 1, which shows a failed tail rotor drive slip joint centering pin. The centering pin, which failed in bending at the section where it enters the slip joint yoke, is shown above the yoke with the remaining portion still left in the yoke below. This pin is pressed into the yoke on the tail rotor drive shaft and is used to locate and center the cam follower tee in the cam of the slip joint yoke itself.

In the original design, the intent was that the pin would act as a centering device only, and therefore would have little or no bending moment imposed upon it. However, the tolerance buildup and misalignment problems of the entire tail rotor drive installation were not properly considered. High oscillatory bending stresses were found to be present in the pin due to these causes.

This condition was relieved by shortening the pins and opening the tolerances so that the possible angular misalignment in the system could be taken by the joint without producing a bending moment in the pin. Again, this failure would be classified in the detail design error category.

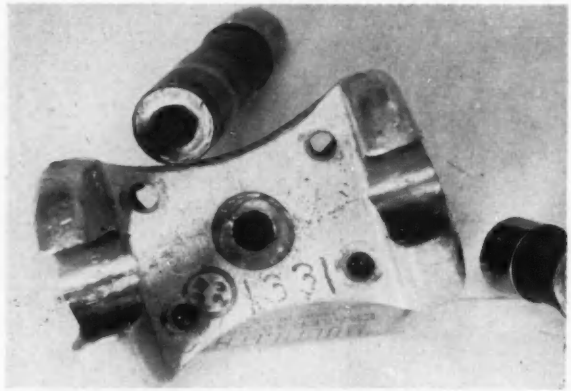
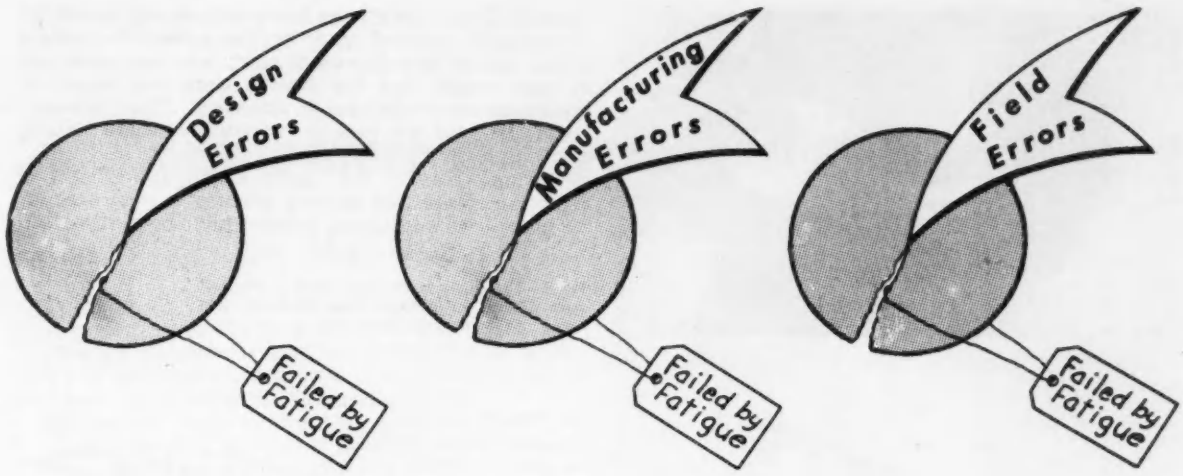


Fig. 1—Failure of this centering pin came from unanticipated oscillation. That brought about a binding for which the part wasn't designed



Three Kinds of Mistakes

Case 2: Surprise Load Goes on a Bender

ANOTHER factor leading to failures due to design inadequacies is the lack of knowledge concerning the load spectrum. An excellent example of this is the failure shown in Fig. 2. This photo shows the fatigue failure of a tail rotor pitch change push-pull rod.

The original design of the part was based on calculations which, at the time, seemed quite realistic. The small loads found gave rise to the selection of SAE 1095 steel drill rod. These loads were determined, however, without much thought being given to any possible resonance phenomena or chordwise unbalance effect.

Bending loads, determined by flight tests, were found to be considerably higher than those calculated. They occurred in an alternating fashion at a frequency of one and three per revolution of the tail rotor. The one-per-revolution bending was attributed to lack of chordwise balance. The three-per-revolution bending was traced to the fact that the torsional natural frequency of the tail rotor installation was about three per revolution.

Had these conditions been in any way appreciated during the initial design phases, the part would have been designed accordingly.

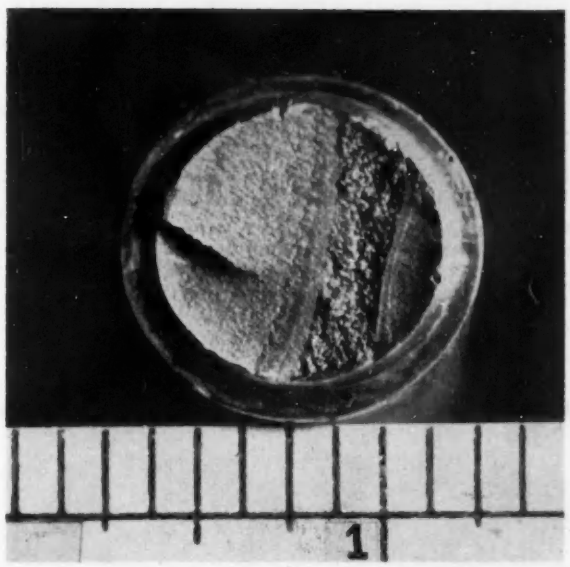
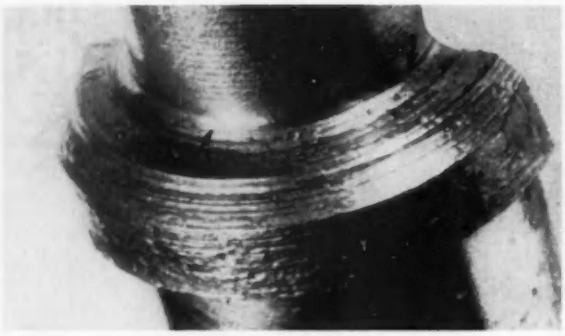


Fig. 2—Loads higher than those anticipated by the designer were responsible for the fatigue failure of this push-pull rod

Case 3: Where Chrome Plate Was the Villain

FIG. 3 shows the SAE 4130 steel collective pitch incidence arm used on the 360 series helicopter for applying collective pitch to the main rotor blades. The arrow points out the cracks in a fillet radius which brought about the fatigue failure of the part.

This part receives both steady and oscillatory



loads in flight, which are the aerodynamic reactions to the pilot-applied loads on the collective control stick. After very thorough study and examination, it was found that the cracks were the result of hydrogen embrittlement in the steel. The hydrogen embrittlement was brought about by chrome plating the part.

Chrome plating has been discontinued and a cadmium plate and baking process is now used in its place. No additional failures have been reported.

Fig. 3—The cracks in the fillet radius of this part were traced to hydrogen embrittlement, produced by chrome plating

Manufacturing Errors

. . . fatigue thrives on little blunders

Case 4: Inspection's Error of Omission

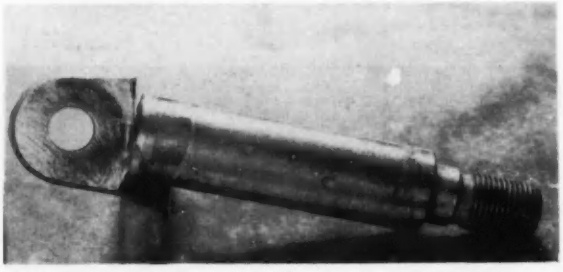


Fig. 4—The manufacturing department failed to put a fillet radius at the critical cross-section change of this drag pin. It slipped by the inspection department. Result: a premature fatigue failure

FIG. 4 is a photograph of a failed steel drag pin. This pin is located in the main rotor system and performs the function of reacting the aerodynamic drag and torque loads imposed upon the rotor blades. For this reason the loads are high and are of an oscillating nature.

Since the actual loads were measured in the flight vibratory stress program, during the certification of the helicopter, the design was made intelligently and was quite adequate.

However, due to a manufacturing error that was not detected by the inspection department, the particular part shown in the figure was accepted and installed on a production rotor system with *no* fillet radius at the change in cross-section. A very high stress concentration then existed and the part failed in 1200 hr of service.

Case 5: Inspection's Error of Comission

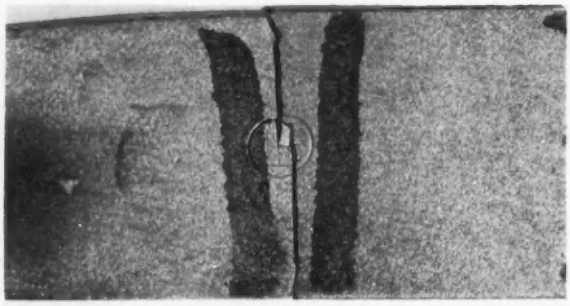


Fig. 5—Strange as it seems, the very metal stamp impression used by an inspector to okay this part caused the part to crack

ANOTHER example of failure due to manufacture is shown in Fig 5. The photograph is of the center section of a cantilever beam which operates as a vibration damper in the cyclic control system.

The failure took place, not at the root or clamped end of the part, but at a section half way out to the tip. As is indicated, the crack is coincident with the metal stamp impression placed on the part by the inspector.

A detailed examination of the part showed that the crack actually had its origin at the steel stamp impression.

Field Errors

. . . maintenance men get careless

Case 6: Abuse, Not Use

TYPICAL of the failures stemming from errors in operation or in the field is the one shown in Fig. 6. The part shown is a failed cyclic control push-pull rod and the failure took place where the rod end bearing attaches to the plugged tube.

The control loads in this part are low. However, the rod is located in such a position as to make it a very convenient hand hold to be used by maintenance personnel. Such was the case, and the failed rod was found to have a considerable amount of permanent set prior to the fatigue failure.

Of course, the eccentricity caused by the (initial) bending set in the rod allowed the in-flight axial loads on the rod to produce alternating bending stresses in the rod end shank. This brought about the ultimate fatigue failure.

There is no question that this failure was directly caused by the maintenance personnel. It should be pointed out, however, that the opportunity was provided by the designer, and as such, could be considered as a failure originating in the design stage.

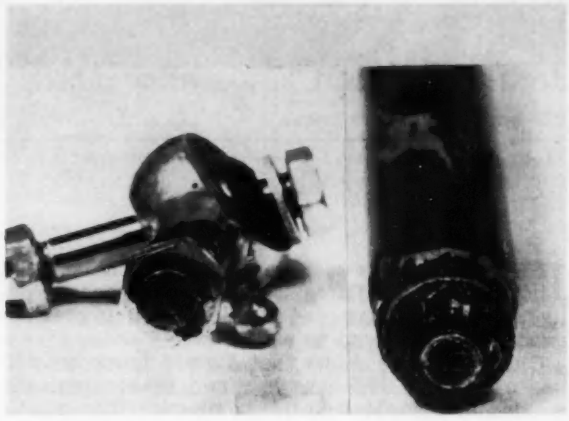


Fig. 6—Mechanics used this control rod as a hand hold as well. That was one job too many and the part failed in fatigue

Case 7: The Case of the Muscle-Bound Pilot

FIG. 7 is a picture of eight studs that quite obviously failed in fatigue. These studs attach the mercury clutch to the engine flywheel and transmit the full engine torque from the flywheel to the clutch.

Their failure is an interesting one, considering its origin. The following is a direct quote taken from the service representative's report on the incident:

"The mechanic reports that at the time of the engine change, the nuts on the subject studs were torqued by the pilot. The pilot did not understand the workings of the torque wrench. It is the type that clicks when the set torque is reached. The pilot was of the opinion that the wrench released when the correct torque was reached. As the last nut was being tightened, the stud broke. This stud was replaced. There is no way to tell how much torque was applied to the nuts at that time."

The studs were apparently all overtorqued, one actually to the point of failure. The other studs, however, went into operation under a very high initial steady stress, perhaps to the point of starting small cracks, and failed after a relatively few hours of operation.

This is an excellent example of a failure caused by an operational error, since these studs normally have an indefinite life.

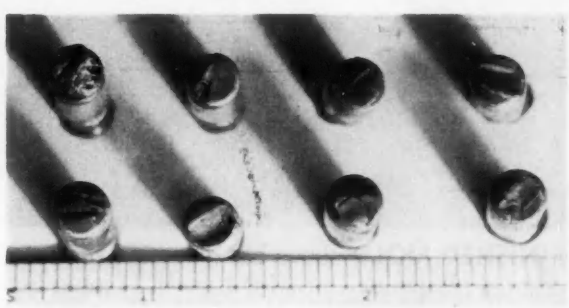


Fig. 7—The malignancy suffered by these eight studs was overtorque. They should have held up indefinitely, but for the overly ambitious pilot who felt that if a little torque is good, a lot of torque is even better

United Parcel's Plastic Truck Body Ushers in

James S. Lunn, President, **and Harry T. Douglas,**
Vice President, Lunn Laminates, Inc.

Based on paper "Fiberglas Reinforced Plastic Truck Bodies," presented at SAE Metropolitan Section, New York, May 6, 1954.

THE plastic truck is here to stay! That's what building United Parcel Service's first package delivery truck of reinforced plastic as well as previous experience points up to us.

Our experience shows that a given truck body in lots of 1000 to 2000 per year can be economically molded in fiberglas-reinforced plastic. The plastic body lends itself to design freedom as well as design change ease. For these reasons plastic tooling looks like the answer. Amortization of such relatively inexpensive tooling over this limited number of parts more than compensates for the higher per pound price of reinforced plastic compared with that of steel or aluminum.

Direct benefits in store for the fleet man are long life and low maintenance. Weighing considerably less than the aluminum-steel type, the UPS reinforced plastic body is expected to reduce maintenance costs. Its relative light weight should help cut fuel consumption. Another maintenance-saving feature is the material's imperviousness to rust, weather, corrosion. The color will last as long as the truck body stays in service. It won't peel or warp since the colorant has been made an integral part of the molded piece.

On the production side, fabrication of glass-plastic bodies is a challenge that's been met. The UPS truck job tells the story. Here it is:

FINISHED MOLD above has a section removed to show the original plaster pattern (light area). Upper body shell made from the mold, which is exactly like the plaster pattern, has a translucent section in roof (pigment has not been added to this section). It furnishes good diffused light inside truck.

MOLDED DOOR is impregnated with color, as are other body parts. Door slides into truck body, allowing for easy driver entrance and exit from cab.

New Era

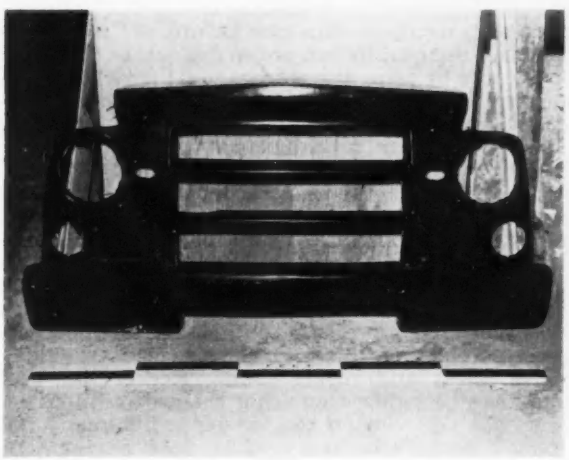
Step 1: Plaster Masters Emerge from Clay Model

We came in on the fabrication picture after the industrial designer completed a scale clay model. It was decided to mold the truck body in 11 pieces. Then we lofted lines onto drafting cloth. Next we transferred the loft lines from the tracing cloth directly to metal. As each template for various sections (such as cab unit, and upper and lower tubs) was completely transferred to metal, the templates were cut out, filed to scribed lines, and prepared for setting up.

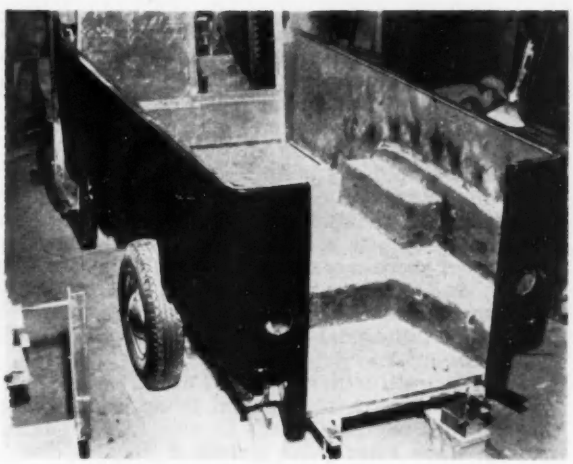
Meanwhile, other crews had established level bases with transit so that templates could be quickly set in place, and oriented in relation to each other preparatory to plastering. Pattern makers filled the areas between templates of each component with wire lathe, applied the rough plaster, and then followed immediately with the smooth finish coat.

Step 2: Plaster Shapes Plastic Molds

After the plaster work, each master was carefully waxed and parting boards were set up on these molds which had to be articulated because of re-



PLASTIC GRILLE for the United Parcel Service truck body is ready for sanding, buffing, and trimming. Ragged edges along the headlight apertures as well as other lines on the grille will be smoothed away in the next operation.



MOLDED BODY here is being assembled to a one-ton, four-wheel chassis. Joined to the lower body section shown here are 10 other reinforced plastic parts. The prototype model is shown at the top of this page. Production models are planned.

entrant angles. Laminating crews moved in with glass mat and resin. They laid glass mat patterns directly on the plaster. With paint brush and roller, they applied polyester resin which had been catalyzed for polymerization at room temperature.

As each segment of the molds was cured, the parting boards were removed and the next segment laid in place and the resin applied. The mold sections then were removed from the plaster, reassembled, waxed, and polished preparatory to molding the parts.

Step 3: Make Parts by Contact Molding

The parts then were contact molded and moved into the assembly area. On production models, the vacuum bag technique will be used. It was felt that contact molding was satisfactory for the prototype from a strength standpoint and that the technique permitted faster proving of each mold. Some of the parts and steps in the process are shown in the photographs on the previous two pages.

Step 4: Join Molded Parts to Truck Chassis

For the assembly operations, UPS furnished us with a modified Ford chassis. The lower tub was placed on the chassis and fastened. The right and left sections of the cab were bolted in the place. Next the upper tub was added, the fenders and fender guard strips were attached, doors and interior details were affixed.

The production model will be molded in more individual components. That'll facilitate molding and save some more weight. Overall styling will be maintained. But by molding smaller components, we'll be able to subassemble in four simultaneous operations. These subassemblies then can be finally assembled on the main production line. That will eliminate any confusion on the part of the assembly crews.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Valve Train Wear . . .

. . . can be mastered more effectively by changes in valve lifter-camshaft metallurgical combinations than by altering lubricants. Laboratory tests need careful interpretation since they correlate poorly with field tests.

Based on paper by **H. L. Yowell, C. A. Weisel and R. R. Risher,** Standard Oil Development Co.

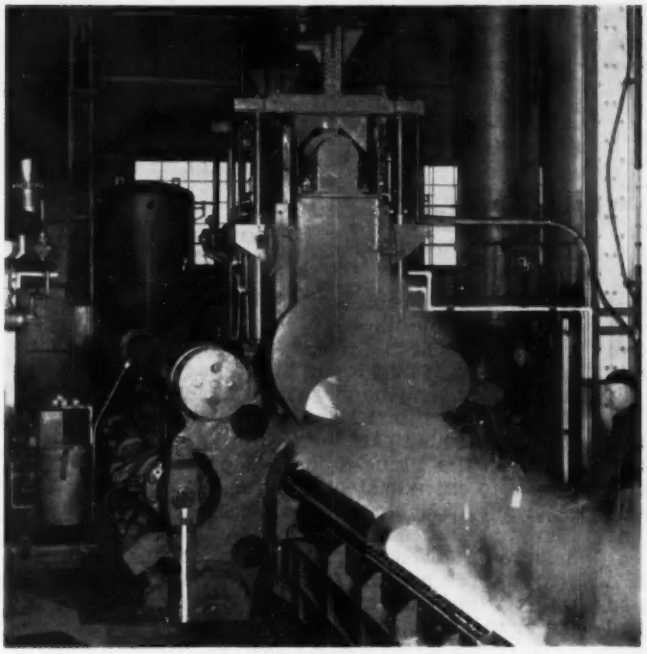
CAMSHAFT metallurgical combinations, engine design, lubricating oil and engine operating conditions have profound influence on valve train wear —a wear which has become a serious problem with modern high compression overhead valve V-8 engines. This is the finding of field tests.

Engines employing different valve lifter—camshaft metallurgical combinations vary widely in their responses to lubricant types. With hardenable cast iron camshafts, chilled cast iron and steel valve lifters wear more rapidly than hardenable cast iron lifters. And it is apparent that a better job of solving the valve train wear problem can be achieved through metallurgical changes than by changes in lubricants.

It was found further that test car driving conditions have a marked effect on lifter wear. With the low to moderate speeds of city and suburban driving, valve lifter wear increased linearly over a distance of 9000 miles. However, when driving was changed to sustained high speed operation, little or no lifter wear occurred regardless of whether the lifters had shown any marked tendency to wear under moderate speed. If, however, the high speed is attempted before proper breaking-in of new valve lifters and camshafts, valve train wear is accentuated with resultant cam lobe failure.

Better wear inhibition properties can be built into lubricants by using the correct "anti-wear" and detergent additive combinations. But whether an increase in lubricant viscosity retards or promotes valve train wear depends upon the metallurgical system used in different types of engines.

Laboratory engine test data has not correlated well with field test wear results, hence they must be interpreted with great care until a better correlation can be obtained. Furthermore, the valve lifter and cam lobe wear experienced in 12,000 miles of field testing cannot be used indiscriminately as an index of wear occurring in other engine parts such as cylinder bores, piston rings, valve guides, valve stems and rocker arms. Rocker arm pad wear can be reduced by using the proper additives, but does not respond to changes in lubricant viscosity. Piston ring and cylinder bore wear, on the other hand, depends more upon lubricant viscosity than additive content. (Paper "A Field Approach to Engine Wear" was presented at SAE Summer Meeting, Atlantic City, June 9, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)



Glass Lube Greases Way for Steel Extrusion

French process extends 3-way gain to designers. Its economics are attractive too.

S. O. Evans, Superintendent of Extrusion, Babcock & Wilcox Co.

Excerpts from paper "Steel Extrusion and Its Value to the Designer," presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 3, 1954.

IT took a molten glass lubricant to bring about a happy marriage of steel to the extrusion process. The method, known as the Ugine-Sejournet process, has increased the length of billets and the ratio of area reduction (called extrusion ratio) available in steel and high-temperature alloys.

This successful union of material and process can furnish the designer three plus values that weren't generally available to him previously. They are:

1. It permits him to use new metals that are difficult or impossible to work by other methods. Aircraft gas turbine rings are a case in point.

2. It provides specially shaped tubes. The outside and inside shapes can be different, such as a tube with a round outside and a shaped inside, or vice versa.

3. It makes available solid shapes difficult or impossible to get by rolling.

The process and its advantages are explained on the following pages

Glass Lube for Steel Extrusion

. . . continued

The Ugine-Sejournet Process: What It Is

The process is like conventional extrusion in that a hot billet is placed in a container between a die and a ram. The ram advances and pushes the metal through a die. The innovation lies in the use of glass as the lubricant.

As Fig. 1 shows, a cartridge of glass is placed between the billet and the die. As the hot billet progresses through the extrusion stroke (it comes in at about 2300 F), it melts the glass and takes on a thin film of it. This provides a continuous supply of molten glass lubricant between the hot steel, the container, and the die.

In the case of hollow or tubular extrusion, Fig. 2, the billet is drilled or pierced before being heated and placed in the container. A mandrel, attached to the ram, passes through the billet and the die so that as the ram advances, the only escape for the metal is through the gap between mandrel and die.

The resulting extruded piece has an outside shape similar to the die opening and an inside shape similar to the mandrel contour. In this case, billet-to-mandrel lubrication is provided by molten glass in the hole of the billet.

The glass used in this extrusion process is no different than that found in ordinary window panes. After extrusion, the glass film is pickled off, so that it in no way interferes with subsequent operations on the extruded part.

Before the Ugine-Sejournet process came along, efforts to extrude steel failed because there was no lubricant available that could maintain a continuous film under required pressure and temperature. Seizure followed lubricant breakdown, which destroyed both bar and die. The glass lubricant holds up as a lubricant and also effectively insulates the die against billet heat.

The process was developed in France by Sejournet in cooperation with the Ugine firm. Licensing is handled by a subsidiary of Ugine. A number of firms in this country are licensed to use the process. In fact, a brass company recently started to use it on a certain group of its alloys.

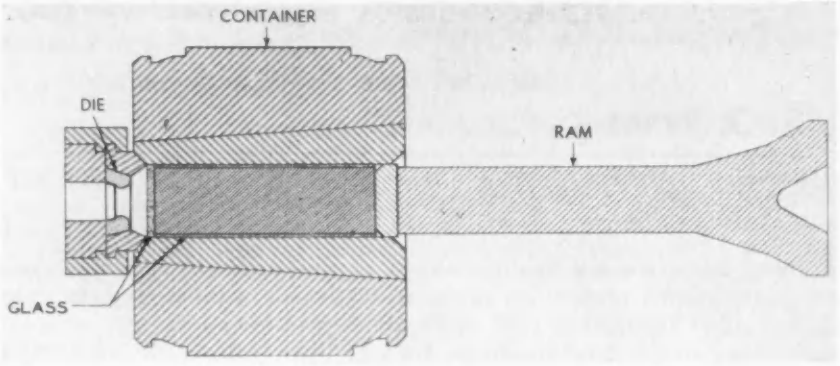


Fig. 1—Here is how a solid shape is extruded by the Ugine-Sejournet process. Note the glass lubricant that coats the billet

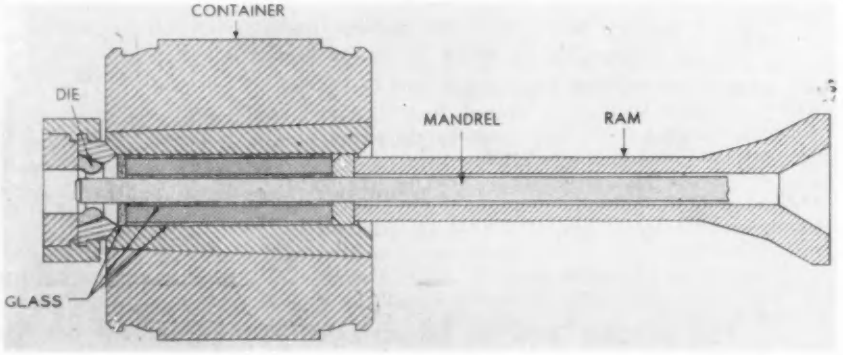


Fig. 2—In extruding tubular sections by the Ugine-Sejournet process, glass also is introduced between the mandrel and the billet

First Design Aid: Tames Tough Metals

The difficulty or impossibility of hot working a metal is a matter of degree. It ranges from the case where conventional working methods result in superficial cracks which must be ground out, to the case where the material breaks up completely. Extrusion has proved of value throughout this range.

The major portion of our early effort at Babcock and Wilcox was directed at the production of stainless steel tubing of the austenitic grades. These materials would be classed as difficult in that tubes produced by conventional rotary piercing methods require a considerable amount of grinding inside and out before subsequent cold work can take place. Extruded tubes required almost none of the costly internal grinding and reduced the external grinding necessary.

More spectacular than this has been the production of tubes in materials that were previously considered "unpiercable" by conventional methods. Tests along these lines have been started recently and are going on continuously. Several alloys have been extruded successfully. One of these, 19-9DL, has passed our laboratory tests and is now offered commercially.

In addition to the tubular work, we have extruded solid bars in considerable quantity of pure and alloyed molybdenum as well as smaller quantities of zirconium, titanium, S-816, M-252, Hastelloy B, and Hastelloy C. These materials have been extruded with varying degrees of success; but in each case some sound material was produced. In this connection, extrusion gives great promise in providing a break-down pass for a cast material where the yield is very low in the normal cogging operation.

Second Design Aid: Complex Tube Shapes No Problem

An odd shaped tube with nonuniform walls may be of advantage either for heat transfer or mechanical purposes. Fig. 3 shows some of the shapes that have been made in France by our licensor, some of which we have made here as well. Four of these shapes are designed for heat transfer between differing materials where either inside or outside extended surfaces are necessary. The center shape in stainless steel has been produced in some quantity in the extruded and cold drawn condition in France for wrist watch cases.

This is a rather spectacular example of a group of mechanical hollow shapes, such as hex nuts and guide sleeves, that may well be benefited by starting with a hollow extruded shape.

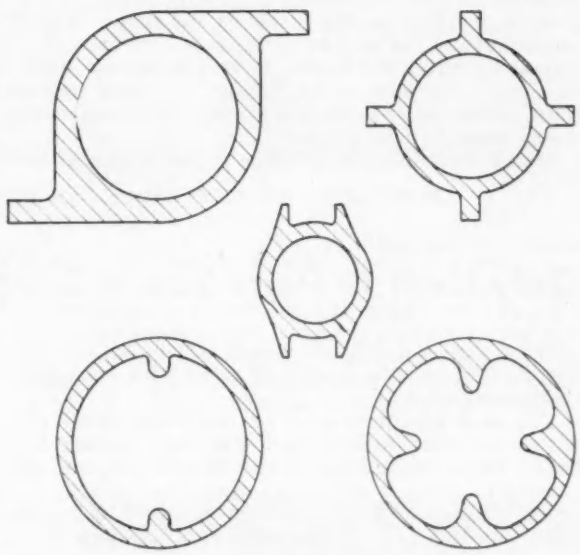


Fig. 3—The glass extrusion process produces all kinds of special inside and outside tubular shapes. Those shown here have actually been made by this method

Third Design Aid: Unusual Solid Shapes in Small Runs

The value of solid shapes off the extrusion press comes from three considerations:

1. Provision of shapes which cannot be rolled or are not offered.
2. Provision of shapes in small total quantities.
3. Provision of shapes in small unit quantities.

The shapes which cannot be rolled or are not offered may be in this category because excessive draft on some section may make the rolling impractical. Or it may be for as simple a reason as that the shape is not offered in the grade of steel desired. Take the case of angles with one leg heavier than

the other, or other simple shapes that are just far enough off the beaten path so that demand has never been sufficient to justify rolls for commercial supply. Such shapes frequently force the designer to resort to expensive machining to fit his need. Many of these shapes may be produced by extrusion.

When relatively small quantities of a new shape are desired, extrusion may well provide an economical source even when rolling is possible, but rolls are not presently available. Tools for extrusion can be produced for about $100 to $150, whereas rolls would cost many times this amount.

Finally, there are many cases where 1000 lb or less of a shape are required at intervals over a long period of time. Large quantities would cause a large investment tied up in the user's inventory; but a small quantity which must support the change-over of a rolling mill would be prohibitively expensive. In steel extrusion, the die is changed after every push so that successive pushes may well produce different shapes. Thus, as small an item as 150 lb or one small billet may be produced as inexpensively as much larger quantities, assuming that the requirement is recurrent so that the die may be used up and its cost may be born over a succession of such small items.

Extrusions Pay Off Where They Cut Out Operations

The discussion of economic considerations and the outlining of fields of application of extrusion are closely related. Notice that the field of application that has been outlined for extrusion is just outside the field of commercial hot rolled shapes.

Extrusion is an expensive process relative to commercial hot rolling. To support this expense in normal grades, the extruded product must yield savings someplace else along the line. In the extrusion of stainless steel tubing for subsequent cold working, this saving results from elimination of expensive grinding on the inside of the tubes. Other sources of savings may be yield, as in expensive materials which either break up excessively or suffer excessive chip loss in machining; or costly operations saved, where the machining operation itself looms large in over-all cost.

Where machining of a shape is the source of the saving, it is generally necessary that a breakdown of the operation shows the machine cutting time to be high as compared with set-up time, because the extrusion tolerances will probably be such that the set-ups and minor machining will still be necessary. Obviously the actual time spent in cutting will have an economic impact both in operational saving and in the elimination of scrap loss in chips.

Obviously the economic significance becomes less where a product is "unobtainable" from other sources. Such a product may be seamless tubes in grades such as 19-9DL, 440-C, or Type 309. Actually, however, some of these items again are in the extrusion field because of economic considerations. That's because "unobtainable" previously meant economically unobtainable because of the prohibitive loss on the mills or the prohibitive cost of producing the part by pure machining.

Only Limit to Parts Size is Equipment

The actual size of parts which may be extruded is determined by the design of press and container tools available.

The over-all dimensions of the shape must fall within a circle which will allow enough die wall between shape and container wall to give adequate die strength.

The minimum area of shape extruded is determined by the ratio of container area to shape area. As this ratio—called the "extrusion ratio"—increases, the pressure within the container increases until a limit is reached at either the strength of the tools or the force of the press. Obviously the resistance to deformation of the metal enters this picture. This resistance is determined by the metal's inherent hot hardness and by the temperature at which it must be worked.

The maximum volume of extrusion, determining the length of piece for a given area, is determined by the size of billet. If the pressure in the container is low, this size is determined by the physical length and area of the container. If the pressures are high the billet length may be limited to something less than that which the container can accommodate.

Combining these factors as applied to the 2500 ton press and the containers available at our plant results in the limits shown in Table 1, as applying to type 304 steel at 2200 F.

The minimum area for a 14-in. billet may be considered as the minimum practical area for each container. Obviously the minima are limitations dependent upon the material and will be more stringent for the super-alloys for high temperature work.

We are now obtaining a container for 4-in. diameter billets to engage in development work in these hot-hard alloys. Such a container has the dual advantage of requiring a smaller billet of the expensive material and also of producing smaller extruded shapes.

In addition to the limitations given above, it appears that a web thickness of about 0.100 in. is a minimum consistent with die filling and tolerable die wear, at least in the containers we have used thus far. Corner radii of 1/16 in. on outside corners and 3/16 in. on inside corners have been held without prohibitive die wear problems.

Dimensional Tolerance Hinges on Shape

Before generalizing on the tolerances available, it is best to point out some of the factors surrounding such a generalization.

First, since dimensional error results from die wear, the stringency of tolerances is tied in with die costs for the extrusion. A loose specification will result in longer die life and lower costs.

Second, again since die wear produces dimensional variation, a section having small area (high extrusion ratio) causes high extrusion pressure, high die wear, and rapid dimensional variation, which is difficult to tolerate on a small section.

Finally, certain portions of dies, such as sharp internal corners, wear more rapidly than other portions so that some dimensions in a specific shape will be more difficult to hold than others.

To give a better general idea of what may be expected, sections having an area of one square inch or more, and having no sections under ⅛ in. in thickness, may be produced with reasonable die life to commercial hot rolled tolerances in normal carbon steel and stainless grades. As the area and section thicknesses go up, this comparison will be more favorable to extrusion. Obviously we would prefer to treat each shape specifically, and frankly we have much to learn along this line at the present time, but we believe the above generalization will give the designer something to work with.

Table 1—Extrusion Size Limits with a 2500-ton Press Using Type 304 Steel

Container Diameter in inches	Maximum Weight of 28-in. Long Billet	Diameter of Maximum Circle to Contain Shape	Minimum Area for 28-in. Long Billet	Minimum Area for 14-in. Long Billet
6.75	260 lb	4 in.	1.23 sq. in.	0.675 sq. in.
7.25	300 lb	4.5 in.	2.06 sq. in.	1.27 sq. in.
8.50	420 lb	5.75 in.	5.80 sq. in.	4.27 sq. in.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Supersonic Flight . . .

. . . raises host of problems in turbojet design. Cooling of bearings, accessories, and casings containing compressor discharge air, must now be considered.

Based on paper by **Joseph S. Alford and Earl L. Auyer,** Aircraft Gas Turbine Division, General Electric Co.

TEMPERATURE is a major problem with turbojet engines designed to operate a substantial part of their mission at Mach numbers between 2 and 3. High engine temperatures—both high ram air and compressor section temperatures—are the result of high speed. At Mach 3, compressor inlet or ram air temperatures reach 600 F, while compressor discharge temperatures reach approximately 1000 F. Temperatures aft of the compressor section will not change appreciably at higher speeds unless new metallurgical or design developments permit raising the turbine inlet temperatures.

A great deal of discussion has centered on the problems of aircraft skin temperature at higher supersonic speeds, but the troubles of high temperatures in the engine are none the less important. Fig. 1 shows the expected temperatures in different areas of the engine. Furthermore, all temperature problems are not metallurgical. Visualize an engine with today's configurations running at full power in an oven heated to 600 F at a pressure of three atmospheres. At present it does not seem feasible to refrigerate enough cooling air to surround the engine with a cool atmosphere.

The high temperatures at higher supersonic speeds create an increased fire hazard from fuel and lube oil. For example, the temperature at the high pressure end of the compressor casing is above the ignition points of most hydrocarbon fuels and lubricants. The engine fire wall must now become a duct

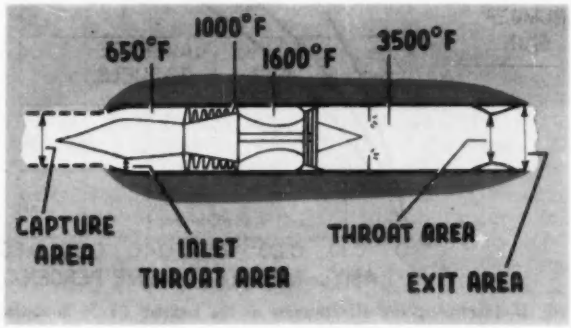


Fig. 1—At higher supersonic speed, these temperatures are to be anticipated in turbojet engines. They indicate the severity of the high temperature problem confronting turbojet engine designers

to bring fuel and lube lines to the engine. Hydraulic mechanisms may not be feasible unless cooled. This may lead to development of more pneumatic systems. Electrical equipment will need special attention. It may be desirable to remove the accessories from the vicinity of the engine and put them in a separate insulated and cooled compartment. All of the engine bearings are now hot-end instead of turbine-end only as before. Refrigeration or cooling of the lube oil will be required. Development of higher temperature lube oils will ease somewhat the bearing and cooling problems. (Paper "Turbojet Engine Design Problems for Supersonic Flight" was presented at SAE Annual Meeting, Detroit, Jan. 13, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Diesel Fuels . . .

. . . must come from greater yields of middle distillate fuel to meet swelling demand. Distillates low in cetane number can be upgraded by use of amyl nitrate additive without harm to engine.

Based on paper by **WILLIAM H. HUBNER**, Ethyl Corp.
W. KING SIMPSON, General Motors Corp.
LAWRENCE J. GRUNDER, Richfield Oil Corp.

CONSUMPTION of diesel fuel is increasing much faster than any other major petroleum product. Hence there is pressure to increase the output of middle distillate fuel and to improve cetane rating with additives.

The biggest single factor in this increased demand is the widespread acceptance of diesel-electric power by the railroads. From using 11% of the total in 1941, railroads came to consume 44% in 1954. If and when total dieselization takes place by 1960, the railroads will account for 50% of the expected nine billion gallon total. Add to this civilian automotive use which has grown from one to 19% within the same period of time and the trend toward greater consumption is obvious.

To meet this rapidly expanding demand for diesel fuels, refiners are finding it necessary to increase the per barrel yield of middle distillate fuel, that is, the "middle-of-the-barrel" fraction distilling between gasoline and residual fuel oil and including kerosene and distillate fuel oil. This gain is being accomplished at the expense of residual yield, partly through coking operations, but mainly through the increased use of catalytic cracking whose end products are essentially high octane gasoline and middle distillate fuel, as compared to lower octane gasoline and residual fuel from the older thermal cracking process.

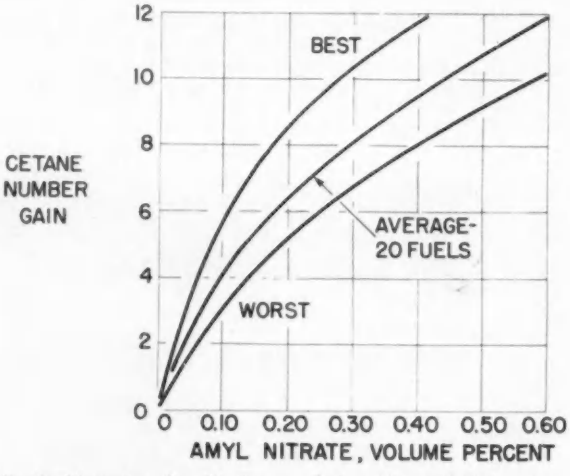


Fig. 1—Illustrating the effectiveness of the additive DB-36 in raising the cetane number of diesel fuels. Cetane response data from 20 fuels ranging from 26 to 55 cetane number are shown, as well as the least susceptible fuel—a 26 cetane catalytically cracked product, and most susceptible—a 47 cetane straight-run distillate

The introduction of cracked distillates in diesel fuels has imparted the desirable characteristics of higher volumetric heat content and lower pour and cloud points, but it has also made necessary paying closer attention to the problems of stability in storage and adequate ignition quality. The deterioration in storage results in discoloration of the fuel and in the formation of both soluble and insoluble residues.

Two types of stability-compatability additives have been developed and a number are now in use. One type consists simply of oil-soluble dispersing agents which control the particle size of the insoluble residue, so as to pass through, rather than clog, the fuel filters. The second type combines dispersant properties with the ability to decrease the rate of insoluble residue formation. No one additive appears to solve all stability-compatability problems in all types of distillate fuels.

The ignition quality of straight-run distillates, expressed in cetane number, varies from about 33 to 68 depending upon hydrocarbon composition, with the paraffins rating the highest and the aromatics the lowest. Catalytically cracked distillates have ignition qualities 5 to 15 cetane numbers below straight-run distillates from the same crude source, depending upon severity of cracking operation. Thermally cracked distillates are about another 10 cetane numbers lower.

Adequate ignition quality (cetane rating) is im-

portant because the only means of igniting fuel in a conventional diesel is by the heat of compression of the combustion-chamber air. It is of most importance during starting and low-load operation when engine temperatures are relatively low, and less important during high-load operation when temperatures are high due to the greater amount of residual heat retained in the combustion chamber. Under both low-load and high-load engine operation, cetane numbers gained with DB-36 amyl nitrate have been found to be equal to natural cetane numbers.

The ASTM cetane ratings of all types of diesel fuel have been found to be improved by the addition of DB-36 amyl Nitrate, regardless of crude source, refining technique, or sulfur content. On the average, as shown in Fig. 1, four cetane numbers can be gained with 0.1 volume %, based on cetane response data from 20 fuels ranging from 26 to 55 cetane number. The least susceptible fuel is a 26 cetane catalytically cracked product, and the most susceptible is a 47 cetane straight run distillate.

It has been our observation that a stove oil of high volatility and low aromaticity could be raised in cold-starting properties from a "failure-to-start" fuel up to the equal of a 50 cetane high-speed diesel fuel with less than a 0.25% DB-36. A cetane improver certainly simplifies the field storage problem and it satisfies the engine which apparently cannot tell natural cetane numbers from those produced by additives. (Paper "Diesel Fuels of the Future" was presented at SAE Metropolitan Section, New York, Jan. 7, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Automotive Finishes . . .

. . . now undergoing strenuous development. Current research to find out why finishes fail should lead to synthesis of coatings having superior chip resistance, color and gloss retention.

Based on paper by **Roy B. Davis,** E. I. DuPont de Nemours & Co.

THE mechanical properties of automotive finishes must be qualitatively classified as "good," but we recognize that certain of these properties fall far short of our desired standards of performance. Chip resistance in particular deserves attention because chipping across the front of automobiles and along the door edges is a commonly complained of defect.

Chip resistance depends primarily on impact resistance of the topcoat and primer and upon adhesion of the primer to the metal and the topcoat to the primer. Thin coats of sheet metal primer are used generally over the hoods and unattached fenders of new cars. Usually the primer is tough, flexible, and quite adherent to the metal. Chipping over this undercoat occurs at the topcoat-primer interface. Improvement must center first on bettering the adhesion of the topcoat to the primer. Further improvement can then come through increasing impact resistance of the topcoat and primer or both.

Undercoats are generally highly pigmented to give good filling and easy sanding properties so that the body surface may be made smooth prior to application of the topcoat. High pigmentation gives these undercoats relatively poor film strength, consequently, when the finish is subjected to impact, the undercoat film breaks and the film chips. As yet, we do not know how to make a good undercoat system having good chip resistance that is easy to sand. Neither have we been able to develop an undercoat having good filling characteristics that requires no sanding. If continued research efforts are unsuccessful, we may have to find a means of handling the tough, chip resistant body undercoats to make possible use of a truly chip resistant body finishing system.

We also recognize that gloss retention of most automotive colors falls far short of our ultimate goal. Black and certain deep brown and deep green colors have excellent gloss retention; they require little care other than washing to keep them clean and bright. Most other colors fall far short of this performance.

Demand for lighter and brighter metallic colors has forced the use of larger and larger quantities of aluminum flake to make these colors as bright and initially attractive as possible. Consequently, these colors dull more rapidly and once badly dulled polishing will not bring back the high gloss. It is the research chemist's goal to make the whole range of automotive colors last the average life of the car without the necessity of polishing to keep them bright. In time, this should be realized.

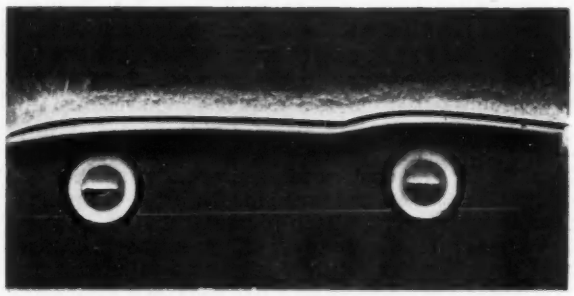
One of the reasons for optimism regarding the future of finishes is the research effort being made to determine why finishes fail and to uncover the mechanism of the chemical and physical processes by which this failure is brought about. The work of Wirshing, and more recently, Sauer, deserves special attention. Once we understand adequately why finishes fail, we should be able to synthesize new finishes which do not have the weak characteristics responsible for the early failure of current finishes. (Paper "Trends in New Automotive Finishes" was presented at SAE National Passenger Car, Body & Materials Meeting, Detroit, March 2, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members; 60¢ to nonmembers).

Stylist and Body Engineer When a Car

. . . Stylist and body engineer get into the act at different times, and admittedly have different primary interests. But far from working at cross purposes, they work hand in hand to get a structurally sound, stylish new body. Both are aware of their colleague's problems—and both see to it that they don't add to them unnecessarily. An example of how this is done is shown in the following picture-caption story.

Stylist Creates a Stylish New Body

1 CURRENT MODEL looks like this. The stylist set these design aims as his goal for the new model: (1) eliminate square, boxlike appearance, (2) lower and lengthen hood, (3) create a light roof effect, and (4) give the feeling of greater overall length.

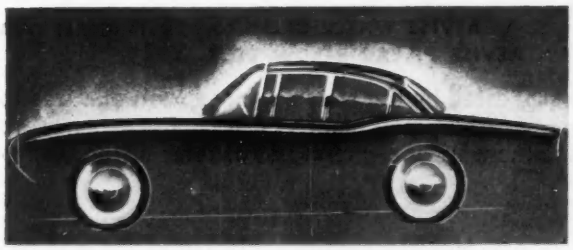


2 MOST IMPORTANT LINE, the fender silhouette, was established first. To achieve maximum length of this line, the headlights were moved as far forward as possible and the taillights moved back. This line was made more interesting by giving it the curvature shown.

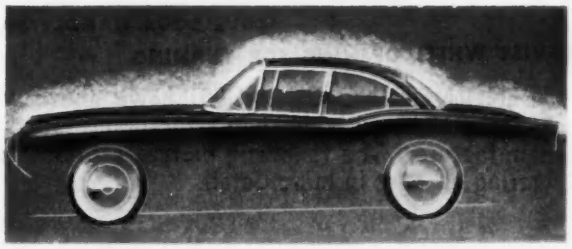
Must Work Together Gets a New Shape

Duncan McRae, Kaiser Motors Corp. and Willys Motors, Inc.
Kenneth E. Coppock, Fisher Body Division, General Motors Corp.

Based on paper "Who Is the Designer—The Stylist or the Engineer?" presented at SAE Summer Meeting, Atlantic City, June 7, 1954. Complete paper will be published in 1955 SAE Transactions. Multilithographed copies can be obtained from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.



3 SUPERSTRUCTURE was considered next. Here the aim was to get a light-looking upper structure, one that would increase the illusion of length. The wrap-around windshield, curved back into the roof, was used to gain still further visual lightness.



4 HOOD AND REAR DECK then came in for attention. It was found that lowering them substantially greatly reduced their length. This also tended to exaggerate the height of the roof. Therefore, hood and deck were compromised for the sake of balanced design.

5 LOWER BODY LINE and wheel cutouts were then established. The lower body line was curved slightly so that it gracefully followed the rest of the design and blended into the wheel cutouts. The wheel openings were made lower than on the current model to give the impression of greater length.

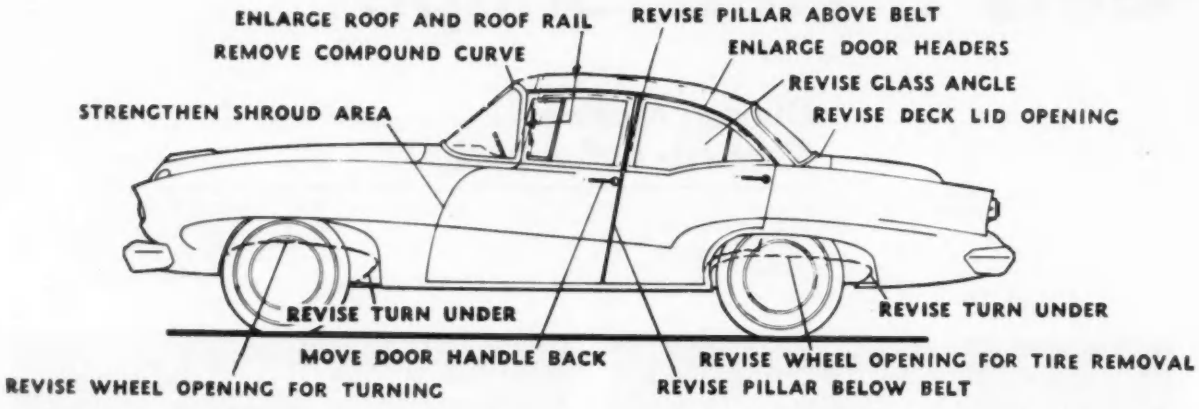
6 PROPOSED NEW MODEL. The stylist has now created a car body that pretty well meets his previously established styling objectives.

Let us now follow the body engineer as he pulls this dream into a reality.

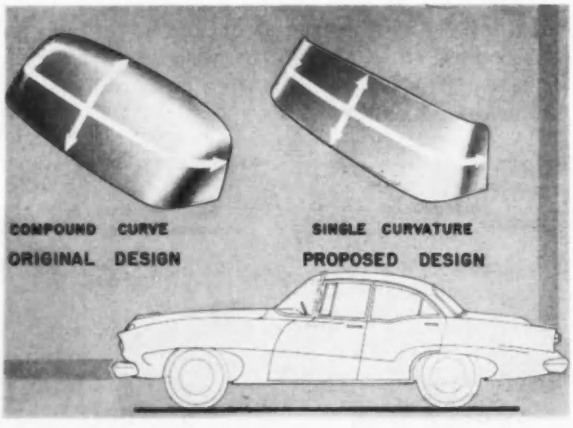
Please turn page

First stylist creates new body . . . then

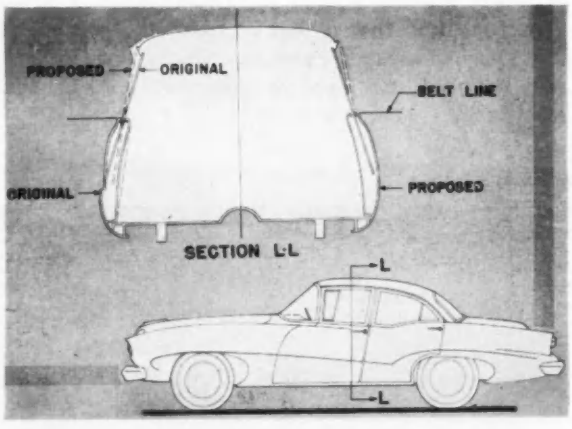
Engineer Gives Body a Searching Look



7 ENGINEERING CHANGES shown above were suggested by the body engineer. His aim was to make the new body style structurally sound, safe, weatherproof, comfortable, and economical to manufacture. The following picture-captions go into the whys and wherefores of some of these engineering changes in more detail.

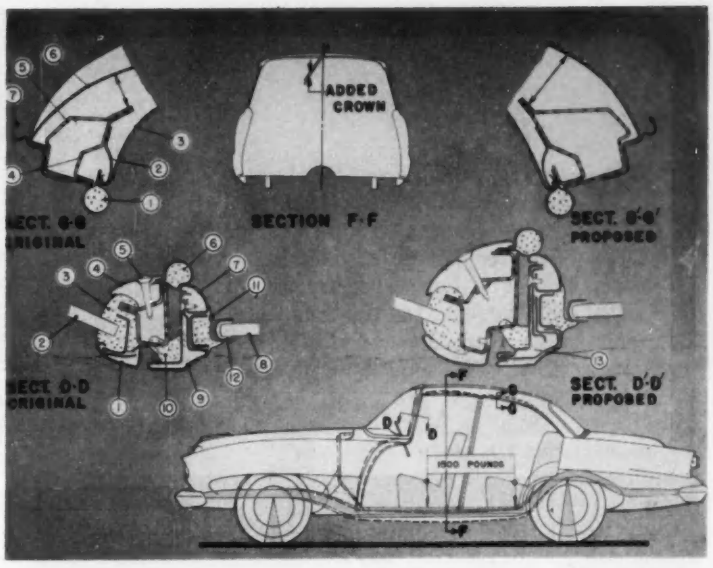


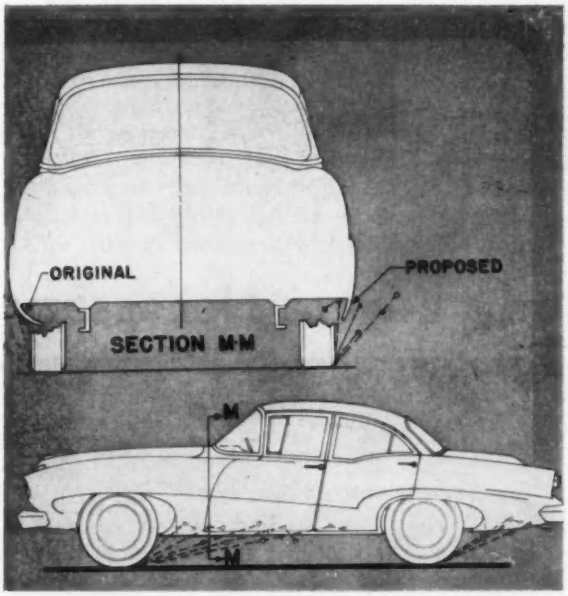
8 SINGLE-CURVATURE WINDSHIELD was proposed as a replacement for the compound-curved one. Manufacturing economy was the reason. It's not easy to bend glass in one direction. Bending it in two directions is even more conducive to manufacturing breakage and rejected windshields.



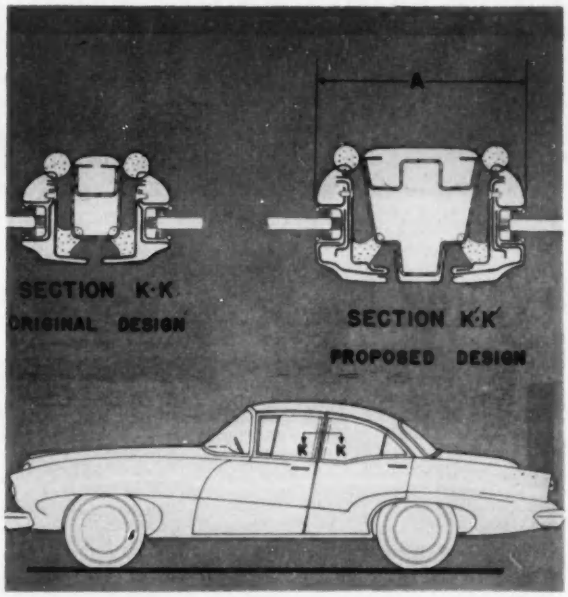
9 DOOR GLASS ANGLE had to be revised so that the window would not contact the door outer panel when it was completely down. This was corrected by straightening the tumblehome as shown above. (Tumblehome is upper portion of section from roof to belt line; lower portion from belt to bottom of body is the turn under.)

10 **WINDSHIELD PILLARS AND ROOF RAILS** (sections D-D and G-G, respectively) had inadequate stiffness when designed to meet the stylist's desire for a light-looking superstructure. Their main structural members were, therefore, increased in area as shown in sections D′-D′ and G′-G′. The body engineer also suggested increasing the thickness of the roof (see section F-F). He felt the proposed roof was too thin for proper handling in fabrication and assembly.





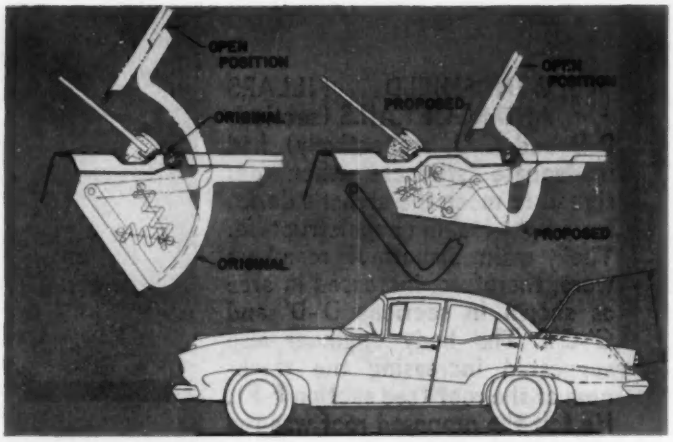
11 **TURN UNDER** in the original design was such that stones and gravel thrown up from the tires could mar the surface of the body. This fault was corrected by moving the lower portion of the body outward. Thus, stones would hit underneath the car instead, causing no damage.

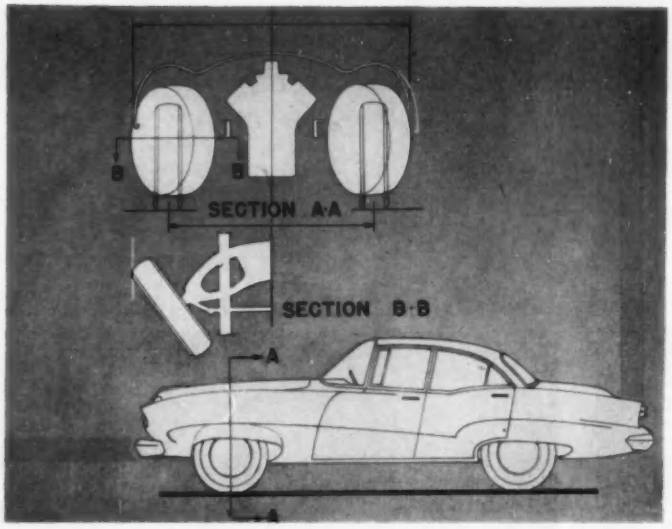


12 **CENTER PILLAR** was structurally inadequate when built to satisfy the stylist's desire for a light-looking superstructure. Therefore, the pillar section was enlarged. The effect of this change on the body design is illustrated by the dotted lines.

Please turn page

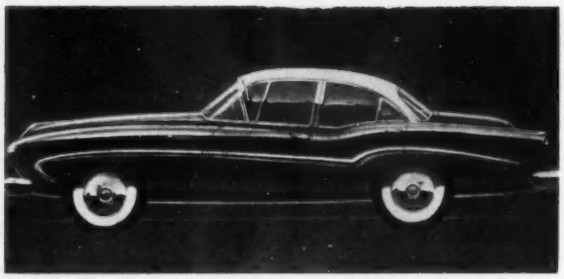
13 TRUNK LID HINGING needed revising also. Originally it required an unusually large hinge to permit the lid to clear the back light and to have sufficient access to the trunk. This hinge could be considerably reduced in size by making the changes shown at the right.





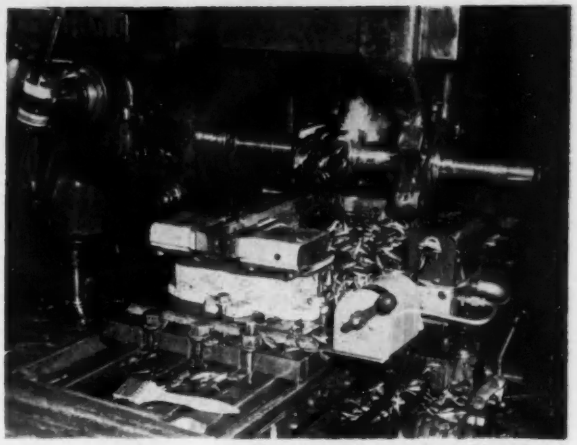
14 FRONT TIRE CLEARANCE was inadequate in the stylist's version. Under a full bounce condition, the fender would interfere when the wheel was turned. This could be corrected by raising the fender line as shown on the right hand side of section A-A.

Stylist Then Reshapes Body Where Necessary



15 ONLY ENGINEERING CHANGES to seriously threaten the original styling concept were those on the windshield and wheel cutouts. It was necessary to restyle the upper structure to bring it back into harmony with the lower body. The roof header was swung forward until it intersected the flat surface of the window angle. The best solution to the wheel-cutout problem was to let the cutouts follow the periphery of the tires and to use a chrome molding to replace the original offset. . . . Together, then, the stylist and body engineer have designed a new car.

- Types of Steel
- Microstructure
- Chemical Composition
- Tool Compatibility



Courtesy of American Machinist

How They Affect Machinability

MACHINABILITY of steels depends on so many factors that it's virtually impossible to come up with a simple guidepost for selecting a material from a machinability standpoint. The material to be machined, the cutting tool, and the cutting fluid all have a bearing on machinability.

In its report, Machinability of Ordnance Steels, Division XI of the SAE Iron and Steel Technical Committee has outlined several broad general principles of machinability. They are based on fundamental properties such as strength, hardness, ductility and microstructure. These principles can be used as the basis for selecting steels with the most favorable machinability consistent with the specifications of the end product.

This article highlights some of the information in the report.

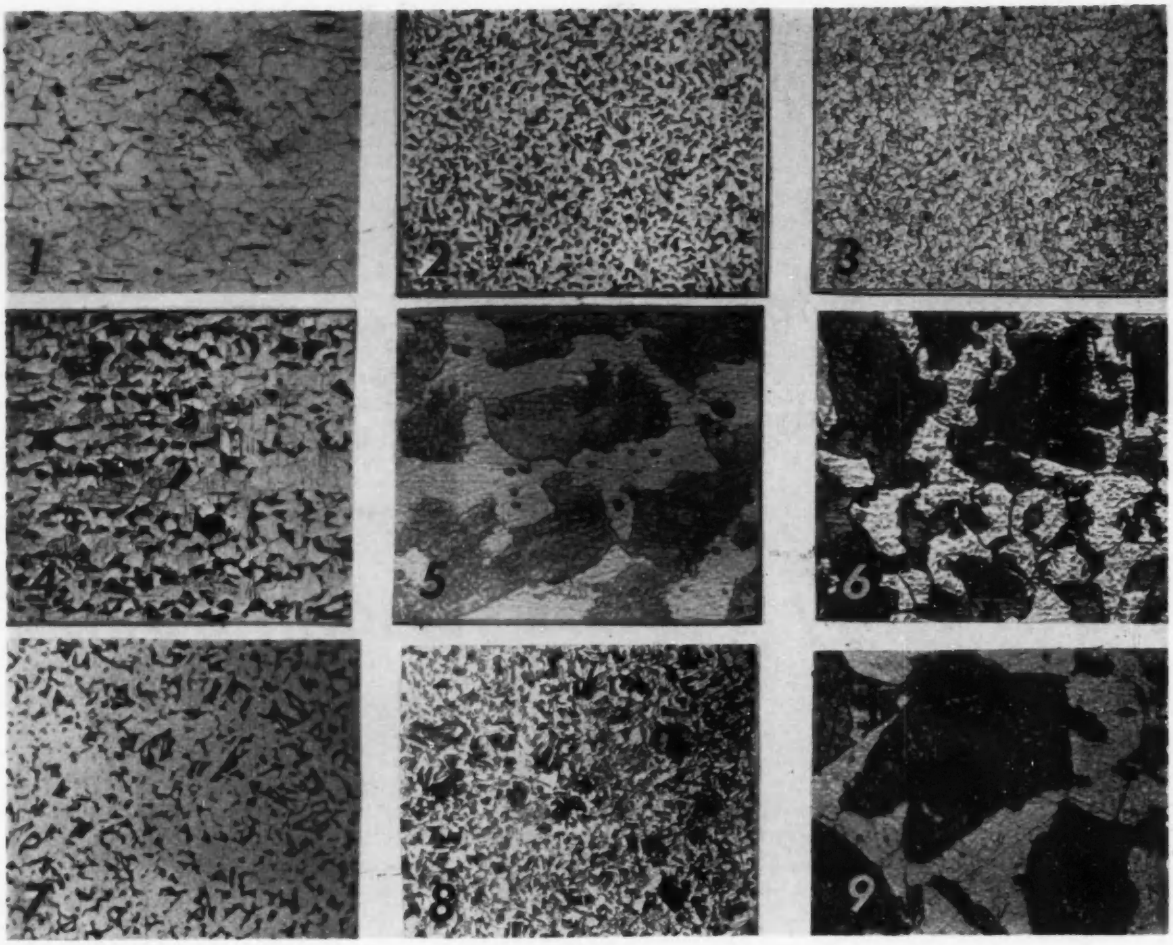
1. Types of Steel

In classifying steels as to killed, semikilled, or capped and rimmed steels, there is a rather sharp distinction between the types of steels when related to machinability.

Killed steels have a controlled austenitic grain size, either fine or coarse, and can embrace all carbon ranges from 0.10 to 1.03 or AISI standard carbon bar grades C1010 to C1095. Likewise, the resulphurized carbon bar grades in the AISI C11xx series can be made as killed steels to an austenitic grain size of either coarse or fine. Alloy steel bar grades for the most part, are made to an austenitic grain size of fine. However, some alloy bar grades are produced as coarse grain with or without added sulphur which is generally applied on critical machining operations such as gun barrels.

Semikilled steels in the carbon bar grades are intermediate between killed steels and rimmed steels. Generally, they embrace carbon bar grades up to and including carbon 0.28, manganese 0.90.

Capped and rimmed steels, in general, are confined to grades within carbon 0.20 maximum and manganese 0.60 maximum. These steels cannot be produced fine grained. For capped steels a de-



Steel No.	Analysis			Condition	Mach. Rating Percent	Brinell Hardness	Yield-Tensile Ratio	Machined Finish	Rake Angle Deg.
1	B-1112			AR	100	121/149	.72/.75	100	10/15
	"			CD	100	174/212	.90/.94	100	10/15
	Carbon	Manganese	Sulphur						
2	.08/.23	.60/1.00	.08/13	AR	70/75	114/131	.61/.69	35/62	15/20
	"	"	"	CD	65/70	153/166	.82/.84	50/73	10/12
3	.08/.20	.60/1.40	.16/33	AR	85/100	118/137	.64/.68	45/70	15/20
	"	"	"	CD	80/100	153/170	.83/.87	55/85	10/12
4	.14/.20	1.00/1.60	.08/13	AR	75/90	126/159	.63/.69	60/70	12/18
	"	"	"	CD	70/85	159/174	.86/.88	68/80	10/12
5	.23/.55	.70/1.00	.08/13	AR	70/80	156/217	.66/.72	65/80	8/12
	"	"	"	CD	65/72	207/235	.82/.89	86/95	8/10
6	.32/.45	1.35/1.65	.08/13	AR	70/75	183/223	.69/.75	75/85	8/10
	"	"	"	CD	65/72	212/235	.85/.89	90/95	8/10
7	.08/.20	.30/1.00	.05 Max.	AR	50/65	101/143	.50/63	10/30	12/20
	"	"	"	CD	46/60	124/170	.80/.86	25/45	10/18
8	.20/.30	.30/1.00	.05 Max.	AR	65/70	146/163	.66/.70	20/43	10/12
	"	"	"	CD	56/64	159/183	.82/.87	35/60	10/12
9	.30/.50	.50/1.00	.05 Max.	AR	60/75	163/217	.66/72	43/75	8/10
	"	"	"	CD	55/70	183/235	.84/.87	60/85	8/10

AR — As rolled; CD — Cold drawn

Fig. 1—Shown above are microstructures of carbon steels. Steels 1, 2, 3, 4, 7, and 8 have been magnified 100 times. Steels 5, 6, and 9 have been magnified 700 times. The table above shows the machinability of these steels

oxidizer may be added to effect a controlled rimming action when the steel is cast. Rimmed steels are characterized by marked differences in chemical composition across the section and from the top to bottom of the ingot. They have an outer rim that is lower in carbon, phosphorus and sulphur than the average composition of the whole ingot, and an inner portion, or core, that is higher than average in those elements. Due to the chemical composition and the metallurgical nature of these steels, there is a decided lowering of machinability and surface finish as compared with killed or semikilled steels. Conditions in metal cutting may be somewhat aided by cold working capped and rimmed steels.

2. Microstructure (Bar Products)

Austenitic Grain Size

As has been discussed, the grain size commonly termed as coarse or fine is controlled by the melting practice.

Coarse grain steels, in general, have three categories, namely:

1. Non-killed steels such as capped or rimmed
2. Semikilled steels, silicon 0.05 to 0.08
3. Killed steels, silicon 0.10 to 0.30 (carbon steels) and 0.20 to 0.35 (alloy steels).

Fine grain steels are so controlled by the use of aluminum or titanium in the deoxidation practice, the exception being those grades which specify vanadium. Silicon is sometimes specified, but as such it has no function in controlling the grain size. However, it may impair machinability.

The austenitic grain size is revealed by carburizing or by the oxidation method and does not necessarily represent the condition of the material when machined. Broadly speaking, both semikilled and killed steels with a coarse austenitic grain size have better machinability than fine grain steels, either as rolled, as forged or when thermally treated by normalizing and/or annealing.

This is especially true for critical machining operations encountered on single and multiple spindle automatic machines, deep hole drilling, internal and external broaching, tapping, and threading. If the steel is thermally treated by quenching and tempering, the austenitic grain size, fine or coarse, is not so significant because of the resultant structures and the relative increase in mechanical properties.

As-Machined Grain Size

As-machined grain size represents the condition of the material when machined. It can result from any of the following operations or treatments: rolling, forging, normalizing, annealing (spheroidite or lamellar), stress relieving, quenching and tempering (spheroidite or tempered martensite).

Figs. 1 and 2 show structures and machinability of carbon alloy steels. The structures are as-machined grain size and represent specimens cut from $\frac{3}{4}$ to $1\frac{1}{8}$-in. round bars produced as follows: as hot rolled, normalized, annealed, and quenched and tempered. Such structures, regardless of the austenitic grain size (coarse or fine), are more representative of the material as machined. Other conditions may include such factors as mass effect, grain coarsening of fine austenitic-grained steels, banded structures, effect of inclusions, etc.

The preceding data show the effects of rolling and rolling plus cold drawing upon the machinability of carbon-steel rounds. Steels represented are AISI compositions C1008 through C1045 and C1109 through C1141, including resulphurized steels.

It is common practice to accept hardness as a measure of machinability, but this property is not necessarily a reliable guide. Two steels of different composition can be of the same hardness, but their machinability usually is not the same. In part, this is true because of the method of processing the steels, whereby there is a difference in ductility, and especially in structure.

The yield-to-tensile ratio is essentially a measure of ductility. Structures with a predominance of ferrite with low hardness and high ductility are machined at slow speeds to avoid tearing. Cold drawing of such steels aids machinability but is dependent upon the work-hardening ability of the given composition and its structure.

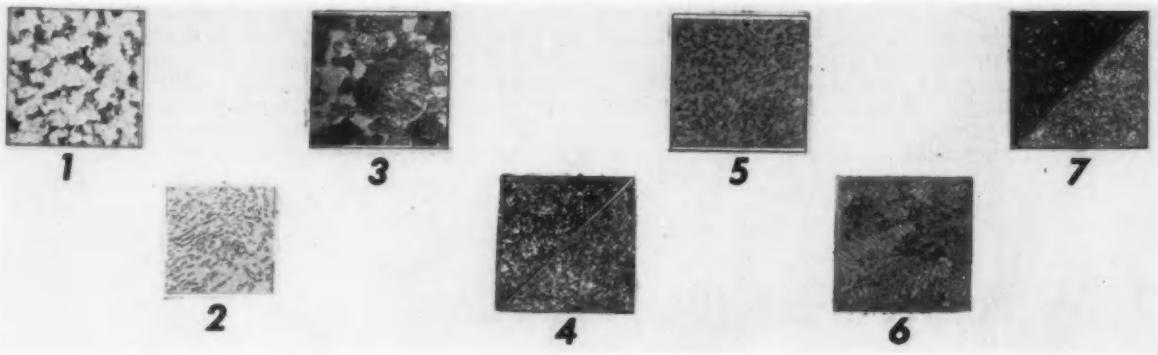
Additional references are made to as-machined grain size contained in USAF Curtiss-Wright Machinability Report, Volume 2, 1951. A caption "Microstructure Determines Machinability" includes tool life charts and photomicrographs of twelve steels as follows: B1112, C1020, 8620, 3140, 4140, E4340, 5140, 8640, E52100, 430, 410 and 347. Expressed as "Microstructure Indexes Tool Life", the order of decreasing tool life for simple turning using carbide tools is shown in Table 1.

Carbide Distribution

This is somewhat synonymous with as-machined grain size. The carbon content essentially controls the amount of carbide constituent which may be present, but distribution of the carbide constituent is dependent upon such conditions as: (1) hot working—rolling or forging, (2) thermal treatment, (3) annealing, (4) isothermal treatment, and (5) quenching and tempering.

The conditions outlined above will tend to alter both the amount and distribution of the carbide constituent depending upon the relative solubility of the carbide within a given chemical composition. Some practical examples of these could be as follows:

1. Take the case of batch cooling of forgings in tote boxes, especially carbon and low alloy grades



Steel	Carbon %	Condition and Structure	Mach. Rating, %	Brinell Hardness	Yield-Tensile Ratio	Machined Finish	Rake Angle, Deg.
1	.08/.30	Normalized or annealed	59/82	149/202	.47/.71	21/50	8/18
	"	Cold drawn	41/75	174/229	.67/.84	39/61	8/16
2	.30/.50	Spheroidized anneal	60/85	146/202	.50/.70	16/30	8/15
	"	Spheroidized CD	47/75	179/235	.70/.86	30/50	8/12
3	"	Lamellar anneal	54/74	156/212	.56/.75	60/83	6/10
	"	Lamellar CD	41/65	192/248	.76/.90	76/90	5/10
4	"	Heat-treated	12/45	229/352	.75/.90	80/100	5/8
	"	Heat-treated CD	10/36	248/352	.81/.93	90/100	4/8
5	.50/.70	Spheroidized anneal	49/70	174/217	.70/.84	21/41	6/10
	"	Spheroidized CD	40/60	202/255	.80/.91	40/60	5/10
6	"	Lamellar anneal	30/58	197/255	.75/.90	70/90	5/10
	"	Lamellar CD	22/52	235/285	.87/.95	90/100	5/8
7	"	Heat-treated	12/40	229/352	.75/.92	85/100	4/8
	"	Heat-treated CD	10/25	269/352	.80/.95	90/100	4/8

Fig. 2—Above are the microstructures of heat-treated steels. Steel 1 has been magnified 100 times; the other steels have been magnified 700 times. Machinability of these steels is given in the table

in carbon ranges to 0.30 maximum. Here there is a tendency to produce an excess of ferrite which is highly undesirable for machinability and surface finish, particularly in threading, tapping, broaching, gear cutting, and so forth.

Although not practiced, the same would be true for bars if pile cooled on hot beds. The remedy in the case of forgings is to normalize with a uniform air cool. This will effect a redistribution of the carbide, resulting in either a Widmanstatten or blocky ferrite structure.

2. In batch annealing alloy steels to produce lamellar pearlite (carbon 0.30 to 0.50), the mass effect as related to the bar or forging cross-section, combined with the amount of steel per furnace charge, fixes the cooling rates. Depending upon the chemical composition, if the cooling rate from the austenitizing temperature through the critical temperatures, is too fast, the carbide may take the form of fine pearlite. This fine pearlite has a high constituent hardness and causes increased tool wear during machining. On the other hand, coarse pearlite has a lower constituent hardness and, with about 50% plus dispersion, it is the preferable structure for machinability.

Uniform pearlitic structures are sometimes difficult to produce on a commercial basis in batch or pit type annealing furnaces. Best results are attained by isothermal annealing, which usually requires two batch type car bottom furnaces or a continuous cycle furnace. Modern equipment utilizes rotary and continuous furnaces for forgings.

3. Spheroidize annealing is generally associated with high carbon grades classified as carbon steels, carbon in excess of 0.60; alloy steels, carbon in excess of 0.50. Spheroidite is more readily produced than pearlite. However, it requires longer holding times and slower cooling rates. Spheroids of moderate size uniformly dispersed are highly desirable for best machining.

Depending upon the chemical composition, this type of structure may be difficult to produce commercially so that a compromise is sometimes necessary. While spheroidized structures have a high index of tool life with a comparatively high rate of metal removal, the surface finish is rougher than that of pearlitic structure or a tempered martensitic structure.

4. Quenched and tempered structures: It is difficult to prescribe optimum mechanical properties

and hardness, when considering quenched and tempered structures in relation to economic machining. The overall conditions are dependent upon the type of machining involved, the cutting tool material, and the cutting fluid characteristics and applications. For simple machining operations with single point tools, some flexibility in properties can be tolerated. Thus, comparatively hard or soft steels can be successfully machined.

On the other hand, strict control of microstructure and mechanical properties is necessary for the more critical machining operations, utilizing single and multiple spindle automatics, straight and contour milling, broaching, gear cutting, tapping, threading and deep hole drilling or trepanning.

Before leaving this question of carbide distribution in various structures, an opposite condition is sometimes encountered which has to do with excessive free ferrite. In general, free ferrite is the result of an ineffective heat treatment and is more prevalent in oil quenched carbon steels.

An excellent example of this is the carbon grades WDSS3 to WDSS7 in specification MIL-S-10520A, steel for high explosive shell bodies. While these grades are set up to be compatible with the required mechanical properties, heat treating techniques must provide for drastic oil quenching so as to effect the maximum of cooling rates. If free ferrite persists, experience has indicated that it will impart a low tool life index for band groove forming tools and taps used in threading of the shell nose.

Water quenching of carbon steel H.E. shell bodies is suggested. If adopted, this should eliminate the existence of excessive free ferrite and thus would improve the machinability of shell bodies. Use of considerably lower chemistry steel would be allowed with resultant advantages of significant magnitude in (a) improved machinability, prior to quench and tempering operations especially; (b) lower cost steel; and (c) improved steel procurement potential.

Cold Work

In the mechanics of cold work as related to bar products, there are two general practices, namely:

1. Cold drawn bars as produced from hot rolled bars, are pickled to remove scale, limed, and then drawn through a die. This provides for sizing to roundness, close tolerances and a bright finish. The magnitude of cold work depends upon the per cent of cold reduction for a given cross-sectional area. For example, using 1/16-in. draft, the respective cold reductions are: for a ¼-in. round 36.0% to a 4-in. 3.09%.

2. Cold shaping which, for the purpose of this report will be designated as cold extrusion (backward or forward), is currently being used in the production of shell bodies, mortar bodies, rocket bodies, and cartridge cases. The magnitude of cold work is generally in excess of 40% reduction of the cross-sectional area to develop required

Table 1—Tool Life as Related to Microstructure

Index No.	Structure	Brinell Hardness	Condition
8	10% Pearlite	100–120	Hot Rolled
6	25% Pearlite	120–140	Hot Rolled
5	Spheroidized	160–180	Annealed
4	50% Pearlite	150–180	Annealed
3	75% Pearlite	170–190	Annealed
2	100% Pearlite	180–220	Annealed
1	* Martensitic	280–320	Quenched and Tempered
0.2	* Martensitic	370–420	Quenched and Tempered

Decreasing Tool Life

* (Tempered Martensite)

mechanical properties of yield strengths up to 85,000 psi minimum, yield to tensile ratio 0.90 minimum, and hardness up to Rb 102, Brinell 248/255. These mechanical properties are developed from such SAE steels as: 1010, 1012, 1015, 1017, 1018, 1020, and 1025.

The relationship of cold working to machinability is somewhat varied. Elementary, of course, is the fact that the product has the scale removed and is produced to close tolerances. Technically, "Cold work brings the greatest improvement in steels that have a low order of work hardening and a high order of work embrittlement." (ASM Metals Handbook, 1948 Edition, page 370) Bessemer steel is an excellent example by reason of the high residual phosphorus and nitrogen which embrittle the ferrite.

Moreover, the AISI B11xx and C12xx grades as rolled and cold drawn, have relatively low hardness with low ductility, the optimum values for B1112 and C1212 being Brinell 192 and yield to tensile ratio 0.92. Such a combination, when supplemented with high sulphur, provides an ideal combination for maximum machinability.

With the advent of cold extrusion where the cold work is in excess of 40% reduction of the cross-sectional area, the whole concept changes. For example: SAE 1010 (0.729 in. dia.) forward extruded with 40% cold reduction, produced mechanical properties of: tensile strength 91,250 psi, yield strength 0.2% off set—85,300 psi, elongation in 2 in. 15.62%, reduction area 54.95%, Rockwell B 88 (yield/tensile ratio 0.935). For SAE 1020 with the same cold reduction, the mechanical properties are: tensile strength 104,800 psi, yield strength 101,166 psi, elongation in 2 in. 9.37%, reduction area 36.25%, Rockwell B 92.3 (yield/tensile ratio 0.925).

It is well known that grades SAE 1010 and 1020 are notoriously poor machining steels. However, with a high order of cold work, machinability is greatly enhanced. At present 2.75 in. U. S. Navy Rocket Bodies, SAE 1010, and 105 Mn shells, SAE 1012 and 81 Mn M43A1B1 mortar shell, SAE 1010, all cold shaped, are being readily machined in production.

Nonmetallic Inclusions in Steel

Any specimen of steel when examined microscopically will reveal the presence of inclusions. The presence of inclusions results from normal

steel-making practices, or are purposely introduced to improve machinability.

The machinability or free-cutting quality of most steels is markedly enhanced by an increase in sulfur content. Such an increase produces more numerous or larger sulphide inclusions. How far the improvement will continue with increasing sulfur has not been determined, but apparently it continues up to a point where sulfur content makes the steel all but unrollable. Although other factors than the addition of sulfur may also affect machinability, it is believed that the actual presence of the sulfide inclusions has the greatest effect.

This effect may be explained by some on the basis of the discontinuity effect of sulfides. Selenium, which forms selenides with the general appearance and characteristics of sulfides, and the presence of metallic lead in leaded steels, have much the same effect as sulfur on machinability. "The qualities of a steel that should make it free machining are low strength, low ductility, and the presence of some constituent to break up the continuity of the ferrite; 'low strength' because less power will be necessary for the cutting tool to tear the metal apart, 'low ductility' so that the chip will break away more readily once the cutting action is started, and 'some constituent' to break up the continuity of the ferrite and give it support so that the tool will be able to cut from one inclusion to the next instead of cutting its way through an unbroken mass of ductile metal." (Quoted from "Metal Progress," 1948, page 60, by J. D. Armour.)

However, recent studies based on direct measurement of the effects produced (ASM Transactions, Vol. 41, 1949, pp. 647–672, "Basic Reasons for Good Machinability of Free Machining Steels," by M. E. Merchant and N. Zlatin), showed that the improved machinability of high sulfur steels and leaded steels is actually due to a reduction in friction between chip and tool by the sulfide or lead inclusion. The measurements showed that the presence of sulfide or lead inclusion does not reduce the strength of the metal ahead of the tool or cause the chip to become discontinuous, but that the chip breaks away more readily only because it curls more tightly due to lowered chip friction.

A still later study (ASM, 1950, Machining—Theory and Practice, "Metal Cutting Research —Theory and Application" by M. E. Merchant) showed that the size of the sulfide inclusions is also important. Large sulfide inclusions are more effective than fine ones in reducing chip friction.

"Refractory oxide inclusions, such as silicates or alumina, have been designated as distinctly harmful to machinability because of the abrasive action, although the case against them is circumstantial, largely because of the experimental difficulties involved in measuring their abrasive effect. On the other hand, some chromium oxides have been credited with improving the machinability of austenitic stainless steels. (Quoted from page 450 of "Metals Handbook," 1948 edition.)

3. Chemical Composition

Chemical composition, evaluated as a single element or as a combination of elements, may embrace all conditions from melting to the end product. Typical examples are:

1. The addition of sulfur for machinability.
2. The addition of silicon for the improvement of soundness and surface quality of the rolled product.
3. The addition of aluminum to produce fine grain steel.
4. The addition of alloys for deep hardening.

It is a known fact that chemical composition has a definite effect upon both machinability and surfaceability. To appraise respective cutting speeds or production rates in machining covers a tremendous scope when related to the many AISI or SAE standard and tentative standard steels.

Chemical composition influences both the type of structure and the amount of constituents in the structure. These factors, for wrought products, depend upon how the steel is cooled after mechanical working (as hot rolling or hot forging) or how the steel is thermally treated (normalized, annealed or quenched and tempered). If comparable cutting speed levels are to be attained with differences in chemical composition, the product should be so processed as to have the same structure and the same hardness within practical limits.

4. Compatibility of Tool Materials with Work Materials

Fundamentally, the ideal tool material is one that has a high order of red hardness, toughness (shock resistance), wear resistance and thermal conductivity, with a low order of frictional resistance (coefficient of friction). That all of these properties cannot be confined into one tool material

is illustrated by the chart shown in Fig. 3. Here is shown a relationship between red hardness and toughness for five types of tool materials.

(Report on which this abridgment is based, "Machinability of Ordnance Steels," is available in full from SAE Special Publications Department as SP-123. Price: $1.00 to members, $2.00 to nonmembers.)

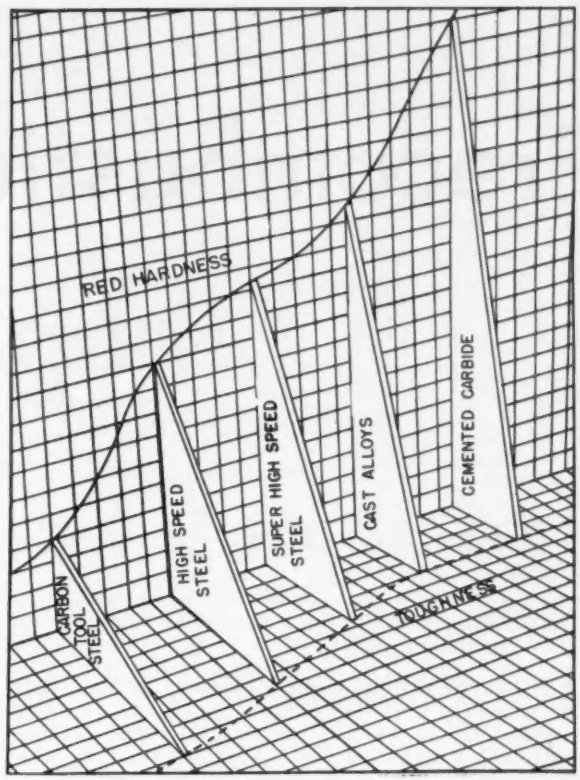


Fig. 3—Compared here is the red hardness and toughness of various cutting materials

References:

ASME Manual on Cutting of Metals, 1939 Edtion

ASME Manual on Cutting of Metals, 1952 Edition (on press)

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SAE Handbook

Tool Engineers Handbook

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Precombustion Reactions Studied by

A NEW engine technique has been devised that makes it possible to study the knock effect of precombustion reaction products in terms of conventional knock-test units, and to establish relationships between fuel reactivity and knock.

Apparatus and Test Procedure

A pair of variable-compression-ratio, valve-in-head, single-cylinder engines of 17.6 cu in. displacement was used. The fuel-air charge was inducted through a standard CFR carburetor and intake manifold by the first, or motored, engine; the charge was compressed, but not fired, and then expanded and exhausted into a manifold leading to the intake port of the second, or fired engine. The motored engine was driven by a variable-speed motor while the fired engine was connected to a constant-speed synchronous motor. Thus, the two electric motors were completely independent of each other. Fig. 1 is a diagram of the apparatus. The fired engine was operated at 900 rpm, with 145 to 150 F mixture temperature, 212 F jacket temperature, and maximum-power spark advance. The motored engine was operated at a speed of 780 ± 10 rpm, the speed required to maintain a pressure of 29.3 in. Hg (the average barometric pressure at Detroit) in the manifold between the two engines.

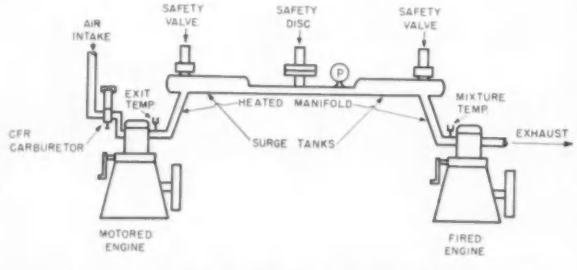


Fig. 1—Schematic diagram of apparatus

The air supplied to the first engine passed through an ice tower, which maintained the air at a constant humidity of approximately 27 grains of water per pound of dry air. The air was then heated to 150 F —the intake air temperature normally used in these experiments. The fuel/air ratio was held at 0.077 to 0.078 as determined by volumetric measurements of the fuel and air inducted into the first engine. The manifold connecting the two engines was approximately 15 ft long and the computed time required for one complete change of gas in the manifold was about 23 sec. This large volume of the connecting manifold was provided as a surge chamber to minimize pulsations. The manifold walls were heated externally in order to maintain a mixture temperature throughout the system of approximately 150 F.

The knocking tendency of the fuel-air charge leaving the motored engine was measured in the fired engine in terms of the compression ratio that resulted in audible trace knock. Frequent calibration of the fired engine over a period of months showed that the knock-limited compression ratio of primary reference fuels could be reproduced within ± 0.05 compression ratio.

The antiknock quality of the mixture leaving the motored engine was expressed in terms of the Army-Navy performance-number scale. For the condi-

New Technique

James M. Mason, Jr., and H. E. Hesselberg

Ethyl Corporation

Excerpts from paper, "Engine Knock as Influenced by Precombustion Reactions," presented at SAE National Fuels & Lubricants Meeting, Chicago, Nov. 6, 1953. This paper is published in full in the 1954 SAE Transactions.

tions used in this work an almost linear relation existed between knock-limited compression ratio and the performance-number equivalents of the primary reference fuel blends. The data shown in Fig. 2 were obtained with the motored engine operated at a compression ratio sufficiently low so that the fuels were undergoing no precombustion reactions. This curve was used for each fuel tested to determine the performance number from the observed knock-limited compression ratio.

With the motored engine operating at a compression ratio such that it was in effect nothing more than a pump delivering fuel and air to the second engine, knock ratings made in the second engine with both clear and leaded fuels were slightly higher than their ASTM Research method ratings.

The technique employed in investigating fuel behavior was as follows: For each fuel the motored engine was operated at a compression ratio of about 5/1 and a measurement made of the knocking tendency of the exit gases in the fired engine. As the compression ratio of the motored engine was increased and repeated knock measurements were made in the fired engine, a point was reached for most fuels at which the antiknock value of the charge from the motored engine decreased. Knock determinations were made at further small increases in compression ratio until the charge autoignited in the motored engine. For some fuels, the antiknock quality of the charge in the fired engine was not affected by the compression ratio of the motored engine, which was limited to a value of 17.25/1 by mechanical interference of the piston and valves. The temperature of the charge leaving the motored engine was measured by a thermocouple located in the exhaust port.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

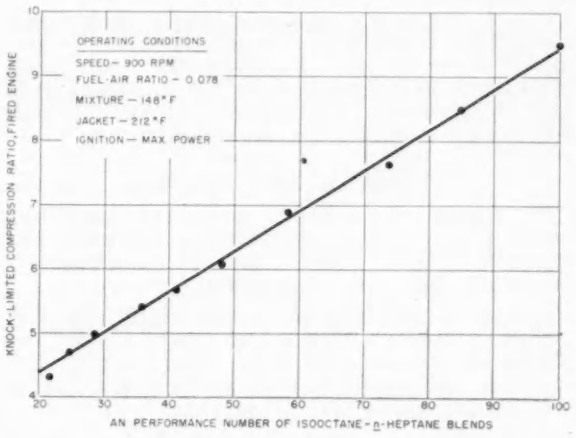


Fig. 2—Relationship between fuel performance number and knock-limited compression ratio

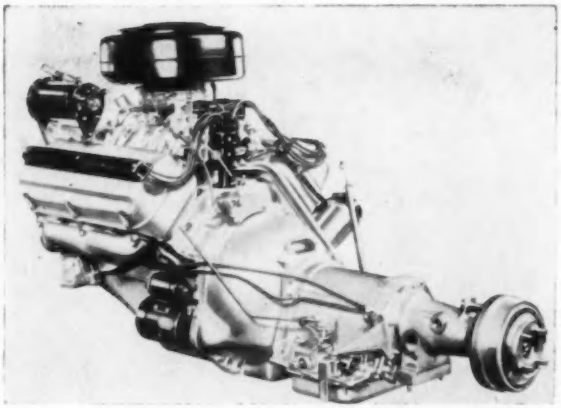


Fig. 1—This shows the relatively neat and compact powerplant assembly that results when the Chrysler FirePower V-8 engine and PowerFlite transmission are combined

Chrysler's

CHRYSLER's PowerFlite transmission consists of a 4-element torque converter supplemented by two planetary gearsets hydraulically controlled by a multiple-disc clutch and two bands. These provide, along with neutral, a driving range, a low, and a reverse.

These functions are easily selected by a steering column lever which has a simple and convenient shift pattern. The selector lever gating arrangement is such that all selections can be made by feel without looking at the indicator. This permits the driver to rock his car while he pays the strictest attention to his driving. The complication of a parking position has been eliminated, and a very powerful internal-expanding parking brake mounted on the rear of the gearbox. This brake has proved to be very dependable, while retaining emergency braking completely independent of the service brakes.

Fig. 1 shows the relatively neat and compact powerplant assembly that results from the combination of the Chrysler FirePower V-8 engine and the PowerFlite transmission. This transmission is used on the Dodge, DeSoto, and Chrysler, on both 6-cyl and V-8 models, and on Plymouth.

Simplified Shift Pattern

Fig. 2 shows the shift pattern on the PowerFlite, together with other gating patterns that have been or are being used. It is felt that the PowerFlite arrangement has these advantages:

1. The neutral position can be easily detected, even in complete darkness, simply by moving the lever against the upper stop. This is doubly important because neutral is the only position in which the engine may be started.

2. The drive position is easily reached simply by moving against the lower stop. Hence, the most used positions require no lever manipulation other than movement between the two stops.

3. The shift from neutral to reverse does not require going through a forward gear, with the danger of the car leaping forward when idling fast.

4. All selections can be made by feel with maximum attention being paid to the road. The convenience and safety of this while rocking the car have been mentioned.

5. The parking position is eliminated. The hand brake behind the transmission provides maximum holding power and will, in fact, hold in any range with the engine at wide-open throttle.

Single-Stage, 4-Element Torque Converter

As previously indicated, the torque converter is a single-stage, 4-element unit comprising an impeller, a turbine, and two stators. Fig. 3 shows a cutaway of the water-cooled unit. We have two converters of different diameters: 12½-in. for all DeSoto and Chrysler 6- and 8-cyl models, and 11¾-in. for all Dodges. The smaller converter is also used on Plymouth Hy-Drive. Since the converters differ only in size, this discusion will be mostly about the larger unit.

The primary goal in the development of these converters was high torque multiplication with low engine stall and overrun speeds. From the point of view of manufacturing, these converters had to be suitable for a very high production rate, have minimum weight, and have the smallest possibility of external leaks. It was also necessary to get a high degree of standardization of internal parts.

In these converters, the impeller is attached rigidly to the crankshaft, eliminating the flexible drive plate commonly found in this construction. Early in the torque converter program, it was found that a flexible drive caused excessive engine main bearing rap. The explanation for this lies in the

PowerFlite Transmission

What It Does and How It Does It

W. R. Rodger and A. J. Syrovy, Chrysler Corp.

Excerpts from paper "The Chrysler PowerFlite Transmission" presented at SAE Annual Meeting, Jan. 13, 1954. Complete paper is published in full in 1954 SAE Transactions.

added inertia of the system, which resists crankshaft deflection.

Impeller blades are straight and radial and are assembled directly into the converter shell by brazing. This eliminates intermediate stampings and provides reinforcement for speeds up to 7000 rpm.

The turbine is also assembled from stampings, with brazed vanes. Both stators are aluminum castings mounted on the reaction shaft. A roller-type internal cam freewheeling unit permits only forward stator rotation. The rollers of these units are individually energized with accordion-shaped wavy springs of stainless steel. The turbine thrust is taken by flanged powdered-metal bushings, and stator thrust by steel-back bronze washers.

Fluid coupling practice is retained in that the assembly is welded around the periphery. Thus, heavy flanges and bolts are eliminated, with resulting lower inertia. Furthermore, a leakproof assembly results. Experience has shown that service requirements are met very satisfactorily with this type of construction.

As previously mentioned, our goal was high torque with low engine stall and overrun speed. That this goal was attained satisfactorily can be seen in Figs. 4 and 5. Fig. 4 shows the performance of the 12½ in. converter with constant input torque. Fig. 5 shows the performance behind the Chrysler FirePower V-8 engine in a Chrysler New Yorker automobile. Note on Fig. 4 that the torque ratio is 2.6/1 at stall, and on Fig. 5 that the stall speed is a relatively low 1490 rpm.

The performance characteristics of these converters are based on many considerations. We believe they represent extremely fine compromises to

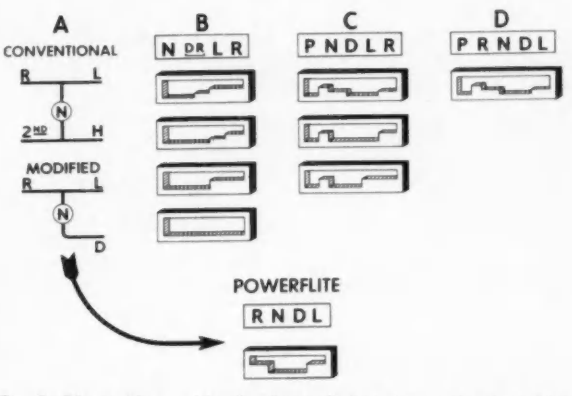


Fig. 2—The parking position has been eliminated from the PowerFlite gating pattern

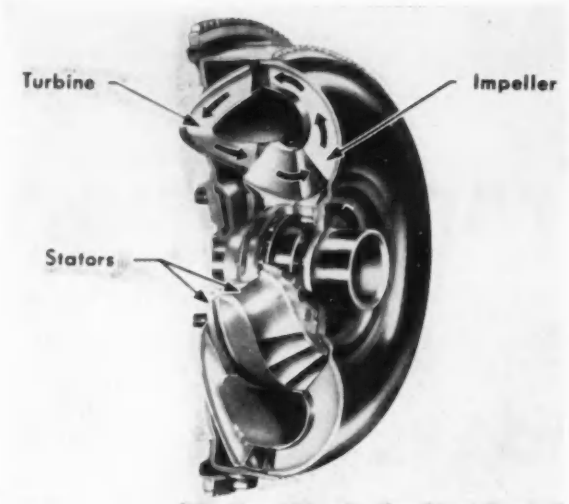


Fig. 3—The PowerFlite torque converter is a single-stage, 4-element unit comprising an impeller, a turbine, and two stators. This unit is water-cooled, others are aircooled

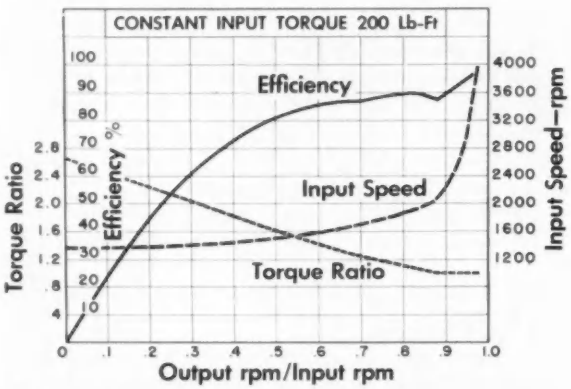


Fig. 4—This shows the performance of the 12½-in. torque converter with constant input torque. Note that the torque ratio is 2.6/1 at stall

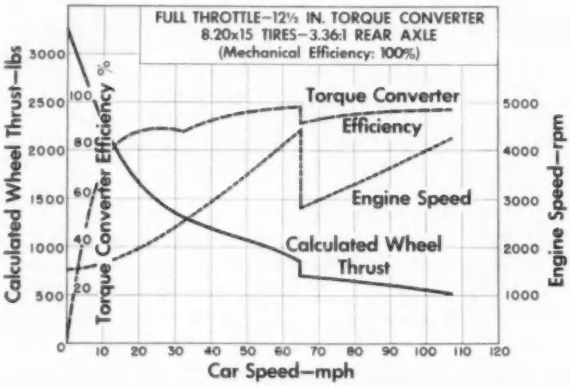


Fig. 5—This shows the performance of the 12½-in. torque converter behind the Chrysler FirePower V-8 engine. Note the relatively low stall speed of 1490 rpm

fit so many models in such a satisfactory manner. Let us examine these characteristics:

1. **Engine Stall Speed:** The engine stall speed was made less than the engine speed for maximum torque, even though performance is better when the stall speed is higher. The higher stall speed results in increased gasoline consumption, greater cooling needs, and, of course, much more engine noise. Two limits were arbitrarily set for maximum stall speed: 1400 rpm in 6-cyl models and 1500 rpm in 8-cyl models.

2. **Torque Ratio:** The Chrysler converters have very high torque ratios to go with 2-speed transmissions. Stall torque ratio is a compromise between satisfactory stall speed, peak efficiency in the torque conversion range, the speed ratio at which the converter reaches the coupling range, and the fluid coupling range efficiency. These ratios are now the highest used in passenger cars. This was achieved by careful combination of vane angles and shapes.

3. **Efficiency:** Efficiency in the torque converter range is more easily obtained with the 4-element unit. However, 3-element combinations have been developed with comparable conversion range efficiencies and superior fluid coupling range efficiencies.

Since a very high percentage of driving is done in the coupling range, the slip in that range is of paramount importance in achieving economy. The speed ratio at which the converter starts operating as a coupling should begin at fairly high speed ratio, say 0.87 or higher.

The use of a torque converter of generous diameter was the most important factor in securing the efficiency in the fluid coupling range. It is also our experience that 3-element converters are the most efficient because there are fewer gaps to bridge in the oil path. As a matter of fact, we are now planning to make the change to a single stator unit in the very near future.

4. **Coasting:** The descent of long steep grades received considerable attention. A torque converter has a very limited ability to drive an engine from the rear wheels, particularly at low car speeds. Our experiments on Mount Washington, which incidentally has the most difficult grade in the country, proved that a converter of ample diameter helps to achieve good coasting performance.

Converter cooling is by water in the larger V-8 installations (Chrysler and DeSoto). This is done in the conventional manner with an oil-to-water heat exchanger mounted on the front of the engine block.

All other model applications are aircooled. This is worthy of comment. Fig. 6 shows the flow of air through a torque-converter housing that may be applied to 6- or 8-cyl models with either size converter. This housing is an aluminum die casting weighing 12 lb. At the rear are four screened openings for letting the air in. On the converter shell are eleven pairs of cooling fins, unequally spaced to prevent noise. These fins pull air through and discharge it at the right-hand bottom side. This

arrangement is capable of handling 280 cfm of air at 1700 engine rpm.

In the development of aircooling, it was difficult to arrive at the proper requirement. It was decided that the most severe condition which should be met would be hauling a 4500-lb trailer up Newfound Gap near Gatlinburg, Tennessee. These conditions were duplicated by towing tests in Detroit and confirmed on the actual grade.

This torque-converter housing is comparatively large and is a new application for die casting in this size. Therefore, a very extensive stress analysis and fatigue testing program was undertaken. Several modifications were made to bolting flanges and sections around the transmission mounting face to reduce stress and to make more efficient use of the material.

Two Planetary Gearsets

The principal components of the transmission gearbox are two planetary gearsets, one multiple-disc clutch, two bands, two pumps, nine control valves, and a governor. Fig. 7 shows the relative location of all these elements.

The input to the gearset is by the front annulus and rear sun gear, with the output from the rear annulus. In operation, all starts are made in low gear, wherein the front sun gear is held by the front or kickdown band. This produces an underdrive ratio of 1.72/1. As the car accelerates, an automatic power upshift is made to direct by releasing the band and engaging the direct clutch, which clamps the front sun and annulus gears together. A kickdown from direct into low gear can be made by pushing the accelerator pedal to the wide-open throttle position. In low range, the controls do not allow the power shift to direct but hold the transmission in the kickdown gear. Reverse is obtained by holding both planet carriers with the rear band. This produces a ratio of 2.39/1. In neutral, all friction elements are disengaged.

Figs. 8, 9, and 10 illustrate schematically the power flow through the gearbox, while Table 1 tabulates the various gear ratios.

The construction of the transmission is relatively simple. The gearset and direct clutch form a compact subassembly which is inserted into the case fully assembled. Exposed at the front of the transmission are the front pump and, behind it, the

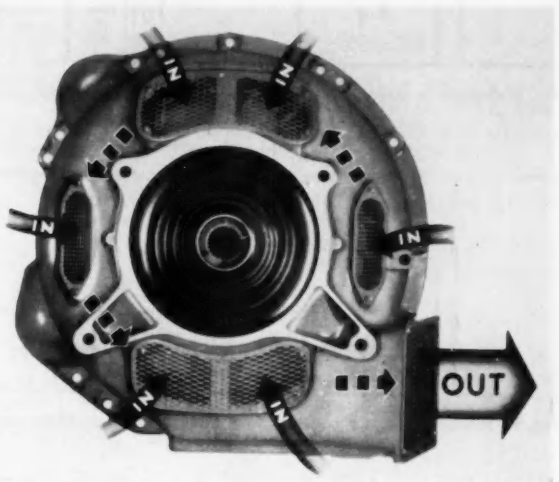


Fig. 6—Air flows through the aircooled torque converters like this

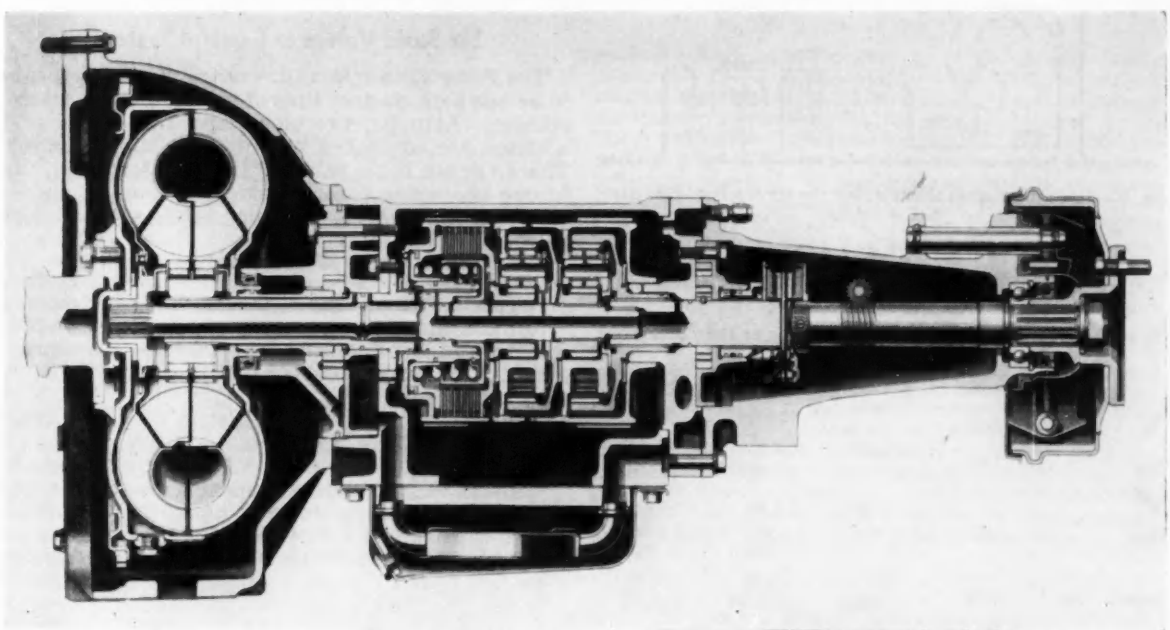


Fig. 7—This shows the relative location of the gearbox components in the PowerFlite transmission

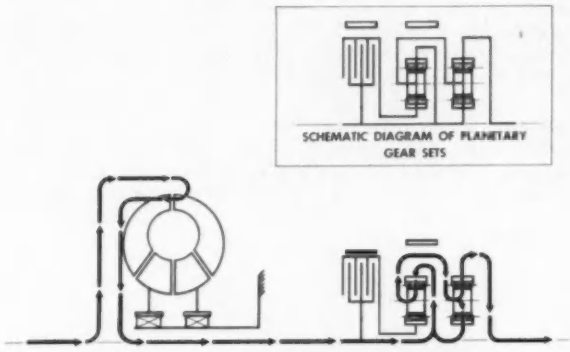


Fig. 8—Schematic diagram of power flow through the PowerFlite gearbox in low

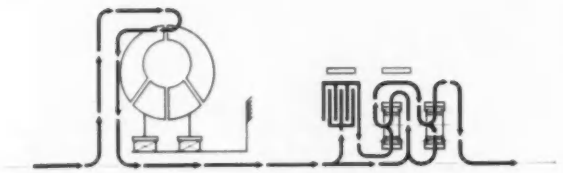


Fig. 9—Schematic diagram of power flow through the PowerFlite gearbox in direct drive

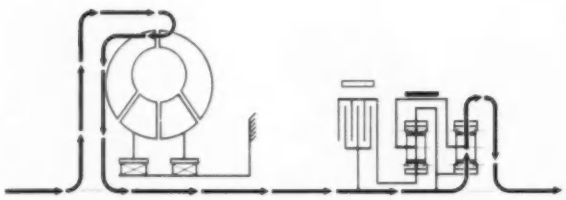


Fig. 10—Schematic diagram of power flow through the PowerFlite gearbox in reverse

Table 1—Transmission and Overall Ratios of the PowerFlite

	Transmission Gear Ratio	Converter Ratio	Transmission Overall	Overall 3.36 Axle
Low	1.72	2.60 at stall	4.47 at stall	15.02 to 5.78
High	1.00	1.60 at 12 mph	1.60 at 12 mph	5.38 to 3.36 at 12 mph
Reverse	2.39	2.60 at stall	6.21 at stall	20.85 to 8.03

regulator valve body. The governor and rear pump are readily accessible at the rear by removing the extension. By lowering the oil pan, the main valve body and transfer plate are accessible and may be removed for servicing. The two band servos are an integral part of the case, removing a potential source of leakage. The reverse band and linkage are all within the transmission and have an internal adjustment for wear. An external adjustment is provided for the low band.

Six discs splined on their inner diameters, and six splined on their outer diameters, form the direct clutch friction elements. The cork and Krafelt lining is placed on the discs splined on their inner diameters. The malleable-iron direct-clutch cylinder is mounted on the reaction shaft extension. Sealing of the clutch aluminum piston is accomplished by an outer neoprene seal and an inner cast-iron ring. Release of the clutch is handled by a 250-lb coil spring. To prevent an unwanted engagement of the clutch due to centrifugal force at high speeds, a bleed valve in the form of a ball is placed in the clutch cylinder.

The front or low band has an asbestos friction material. It is engaged by a servo carrying both line pressure and a throttle-modulated pressure. A resin-bonded matallic friction material is bonded with Cycleweld cement to the reverse band. The reverse servo is actuated by line pressure and is cushioned hydraulically.

Both pumps are of the internal gear type. The front pump is driven by a quill to allow for some misalignment and runout of the torque converter. The quill runs in a bushing and pilots the pump pinion. All parts of the front pump are of cast iron. The rear pump, driven by the output shaft, is similar to the front except for size and materials. The housing is an aluminum die casting and the gears are steel. Hardening of the outer gear is beneficial to the life of the pump.

Six Basic Valves in Control System

The PowerFlite hydraulic-control system appears to be complex, as does that of any automatic transmission. Actually, two oil pumps, two bands, and a clutch are controlled by only nine sliding valves. There are six basic valves: (1) regulator valve, (2) torque converter control valve, (3) manual valve, (4) throttle valve, (5) governor valve, and (6) shift valve.

Here's what each of these valves does:

Regulator Valve: The regulator valve is designed to maintain a line pressure of 90 psi in neutral, drive, and low, and 250 psi in reverse. These pressures are neither affected by throttle position nor by car speed.

When the main control system has been pressurized to 90 psi, the regulator valve directs oil to the torque converter. Further build-up in pressure causes additional movement of the regulator valve, thereby connecting front pump pressure with suction. If, because of rear pump output, pressure rises still more, the valve also directs this oil to front pump suction. The car speed at which the rear pump has assumed full control is termed "crossover" and is approximately 35 mph. This practically removes any head against

which the front pump must work, thereby diminishing horsepower losses.

Torque Converter Control Valve: The oil directed from the regulator valve to the torque converter must pass through the torque converter control valve as it enters the converter, and through a metering orifice as it leaves. With increased flow, the pressure drop across this orifice increases, gradually increasing torque converter pressure. When a pressure of 60 psi has been reached, the control valve at the converter inlet starts modulating the supply of oil delivered by the regulator valve so that converter pressure never exceeds this figure.

Oil leaving the converter through the metering orifice flows to the oil cooler on water-cooled installations and then to the transmission lubrication system. On aircooled transmissions, oil flows directly from the converter outlet to the lubrication system. At normal operating temperatures, this flow amounts to about 10 to 12 lb per min at 25 mph. There is flow through the converter as long as any oil leaves the regulator valve, thus ensuring transmission lubrication at all times.

Manual Valve: The manual valve directs line pressure to the valves and servos employed in the selected operating range. It also serves to increase line pressure in reverse by venting a portion of the regulator valve reaction area.

Throttle Pressure Valve: The throttle pressure valve is one of the valves pressurized in the forward driving ranges. It sets up a pressure that is a function of throttle opening. At closed throttle, this pressure is 15 psi and at wide-open throttle 90 psi. Throttle pressure serves two functions. It modulates band and clutch loads, and it establishes the speed at which an upshift will occur for any given position of the accelerator pedal.

Governor Valve: This valve produces a pressure proportional to car speed. It is used in conjunction with throttle pressure to determine the speed at which the transmission should shift from the 1.72 gear ratio into direct. During a kickdown, governor pressure is used to control the quality of the downshift.

Shift Valve: This valve, with throttle pressure acting on one end and governor pressure on the other, determines when a shift up or down should be made. It feeds oil under pressure to the proper clutching elements during an upshift and drains the oil from these clutching elements during a downshift.

These six valves are absolutely essential to the transmission operation.

Other valves used to refine operation include: Shuttle valve, servo restrictor valve, and kickdown valve.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Excerpts from Discussion

Forest McFarland,

Packard Motor Car Co.

THE overall design of the Chrysler automatic transmission is clean and has been reduced to bare essentials. The control design, in general, follows well-established principles, but, in detail, the design shows Chrysler's solution to the problem present in upshifting and downshifting under all conditions.

In regard, first, to the steering column shift or range selection, Chrysler has chosen the same shifter lever gating as maker C in the Chrysler illustration, except for the deletion of the parking position.

This results in American automatic transmissions having two general types of shift gating patterns: (1) those falling in the B and C groups, which are substantially the same except that those under C have the parking position added, and (2) those transmissions falling under the D group, which would include Chrysler with the parking position deleted.

Many of us had hoped that the last two manufacturers would go along with the pattern previously adopted by the rest of the industry. It is our feeling that maneuvering or rocking the car can be accomplished easiest and best with reverse and low adjacent as in the first groups. We have had no service complaints, to my knowledge, with this arrangement. Reverse can be made inoperative above any predetermined car speed, if desired.

We must agree with the authors that deletion of the parking position does simplify the gating pattern. Many drivers have told us, however, that they use the parking position to provide a quick and positive lock against car movement in preference to the emergency hand brake. These reports have confirmed our original opinion that the parking position is a very desirable feature for both convenience and safety. To answer the question of ruggedness of our design, our engineers thoroughly bent up both front and rear bumpers of cars by driving into a car with the lever in the parking position and sliding the car several feet without damaging the "park" mechanism.

The selection of a 1.72 ratio by Chrysler for the geared drive as the best compromise between a performance gear when starting the car, kickdown gear at highway speeds, and a hill descent gear is interesting. We feel the final answer on the arrangement of the torque converter and gearing for best overall performance for all conditions has not been obtained to date in a commercially acceptable design. We believe this comment can also apply to the automatic stepped-gear transmission. This is no criticism of the units produced to date as Ward's Reports show that since 1940 there has been over 3,800,000 stepped-gear-type automatic transmissions built and since 1948 over 3,400,000 torque-converter transmissions built. The public must like them.

The gearing arrangement adopted by Chrysler appears to be a very straightforward way of obtaining the desired ratios. It would be interesting to know the pitch, pressure, and helix angle of the gears, also if modification is used.

Chrysler's method of welding the converter assembly and

attaching directly to the flywheel certainly simplifies this construction. I am surprised that this type of mounting gave them the best result for crankshaft vibration in bending, in view of previous experience in like cases where a flexible disc with a flywheel or converter mounted on fore and aft bearings has appeared to be the best solution to this problem.

The use of aluminum in the bell housing is a definite advance in weight reduction. Any comments on how stresses were reduced in this part would be of interest, also the overall weight of the transmission.

Selection of Mount Washington for hill test work was of interest to us as a survey of per cent and length of grades in the United States plotted by our engineers with these values as ordinates and abscissas, respectively, showed Mount Washington to be one of two grades that stood well above the general boundary of the pattern.

In summary, we can say, from personal driving experience in the Chrysler New Yorker, that we agree with the authors that this car has a smooth-shifting unit with excellent performance, achieved without doubt at a minimum of cost, complexity, and weight.

H. G. English,
Ford Motor Co.

In the past year, 2-speed converter transmissions have undergone significant changes to improve starting torque This has been done by using higher torque ratio converters or automatically starting in low gear. The Chrysler PowerFlite transmission combines a comparatively high torque ratio converter with an automatic low gear to achieve high starting torque. It is assumed that the selection of the 1.72 low-gear ratio in contrast with the 1.82 of the other 2-speed converter transmissions was to extend the useful speed range of low gear without too great a loss in low-speed engine braking so necessary for car speed control on long downhill grades.

These recent developments appear to indicate a growing requirement for increased performance throughout the speed range. At the same time, it is quite apparent that smoothness of operation must not be sacrificed to any degree.

Also interesting, I believe, is the apparent trend toward larger and simpler torque converters in the interest of a better balance of torque ratio, efficiency in the converter range, efficiency as a fluid coupling, and effectiveness of engine braking. Chrysler's plans to adopt a single stator in the near future is an indication that a favorable balance of important characteristics is still possible with comparatively high stall torque ratios.

Chrysler's extensive use of aluminum die castings in the interest of reduced weight and presumably lower cost is outstanding. I am certain that we can expect still greater application of precision aluminum castings in the future.

The PowerFlite selector pattern with reverse and forward positions separated by neutral is of interest in that Chrysler becomes the second major automobile manufacturer to depart from the pattern established by Hydra-Matic in 1939. As pointed out by the authors, this selector arrangement affords real advantages in terms of safety and convenience.

It is interesting to note that band servos of the PowerFlite transmission are cast integral with the main case. This design results in a rugged case construction and fewer parts through elimination of servo bodies and attaching parts. On the other hand, this arrangement would appear to afford less flexibility in adapting one basic transmission to a series of engines or to future changes in engine output characteristics. The use of high operating pressures for servo application would also appear to present a problem in maintaining sufficiently sound case castings to prevent external leakage of oil through the common case and servo walls.

Over-Maintenance . . .

. . . can be cost bugaboo of fleet operation. Need, not time or mileage, should determine overhauls. Better inspection by better inspectors using better equipment is the key.

Based on paper by **David H. Mikkelson,** Los Angeles-Seattle Motor Express, Inc.

ENOUGH is enough, even of maintenance. Over-maintenance is costly. Too many fleets are being over maintained with resultant excessive costs.

Unit or major overhauls should not be performed at a given time or mileage, but only when the condition warrants them. The problem is to find out when there is need without spending a great deal of money. We must develop ways and means for locating trouble just prior to failure and the way to do this seems to be to have better inspection. This calls for better inspectors and better testing equipment. It doesn't matter who does the inspecting provided the inspection is done by qualified personnel.

To determine the frequency and thoroughness of inspection, a decision must be made regarding the importance of dependability to any particular operation. You can't afford a major breakdown if you are hauling frozen food, or you may lose a payload. That's true with aircraft, too. Breakdown must be avoided at any cost. But there are cases where no serious consequences result.

The frequency with which it is necessary to campaign a fleet for a specific trouble serves as a good yardstick for measuring the effectiveness of a preventive maintenance system. If a certain type of failure is common, the inspection system needs changing. If troubles are varied and a fleet operates well, it tells you the inspectors are doing a good job of checking the proper items at the proper time. (Paper "Can a Fleet Be Over Maintained?" was presented at SAE National West Coast Meeting, Los Angeles, August 17, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

2 CIMTC

Tractor Test Codes

Prove Their Mettle at Ft. Belvoir

A REALISTIC, comprehensive, and unbiased means for judging the true performance capabilities of construction and industrial machinery has long been needed. Recognizing this, the SAE Construction and Industrial Machinery Technical Committee decided three years ago to undertake such a project. More specifically, it set up Subcommittee XII and asked it to draw up performance test codes for crawler and wheel-type tractor prime movers.

The subcommittee recognized from the start that a step-by-step approach had to be taken. First, it made a survey to determine what performance tests might be written. All of them, it felt, would have to live up to these ground rules:

- Be readily understandable by both the user and the maker of the equipment with which it deals.
- Be reasonably unrestrictive as to the place and facility required for its application.
- Be repeatable and controllable within a reasonable tolerance of accuracy.
- Be a practical and indicative measure of the equipment's performance capability within its intended field of application.
- Be impartial in its effect on the judgment of equipment within competitive classes.

The field of useful tests was narrowed down to those tests which appeared useful and controllable to a degree that made their general application practical.

At the present time, these eight tests are in various stages of completion:

1. Reserve tractive ability
2. Vehicle drag
3. Vehicle fuel consumption
4. Speed and acceleration
5. Brake ability
6. Steering loads and turning
7. Grade ability
8. Tilt limitations

The idea in each case is to work out what appears to be a theoretically sound and practical test. Then arrangements are to be made to physically try out—and evaluate—its stipulated procedures.

In the following article . . .

Subcommittee XII reports . . . 1. **What was done**
2. **What was found**

. . . when its tentative test codes on reserve tractive ability and vehicle drag were evaluated at the Engineer Proving Ground, Ft. Belvoir, Va.

. . . in the evaluation of two proposed CIMTC Tractor Test Codes,

What Was Done

INSTRUMENTATION got a lot of attention when the test codes for reserve tractive ability and vehicle drag were drawn up. And this pattern continued in force when the codes were evaluated at Ft. Belvoir, Va.

This may look like overemphasis, but it isn't.

The reason lies in the conditions under which testing must be done. It is a field job with all the handicaps of weather, wind, and dust. The whole test plant must be mobile with no fixed reference points to tie to, and must function at speeds up to 10 or 15 mph. Because space is at a premium, the test crew is limited to a driver for the test vehicle and an operator for the towed load (both of whom have their hands full) and at most two observers. These men may be separated by distances of 40 or 50 ft, a cloud of dust, and the noise of a 200-hp open exhaust. Such conditions are far from ideal.

The test must be run on a level, straight roadway which, if dirt, must be scarified, watered, and rolled to as nearly constant surface conditions as possible. It is difficult to get such a road, or a straight and level concrete road with much over a quarter mile of usable length. Considering that a vehicle at 12 mph will travel a quarter mile in 1¼ min and that the quarter mile must include acceleration and stabilization of operation, the actual duration of test must be short. The Reserve Tractive Ability Code specifies a minimum test distance in feet of 44 times the speed in miles per hour. This means that the instrumentation must be aimed at collecting all necessary data in one half a minute.

Three sets of test equipment were used in the comparative demonstration at the Engineer Research and Development Laboratories Proving Ground: ERDL dynamometer truck, Goodyear dynamometer truck, and Allis-Chalmers dynamometer equipment. It is believed that this equipment incorporates most of the various components now in use for tractive ability and vehicle drag testing.

The basic principle of all tractive ability testing is to have the test vehicle tow a drag load and measure the towing force, the distance travelled, and the elapsed time. The principle of vehicle drag testing is to tow the test vehicle at suitable speed and measure the towing force. (See Fig. 1.)

Two approaches were used in the development of instrumentation at the ERDL demonstration. In one, the equipment was kept as simple as possible. It was arranged to be carried in any available pick-up truck or station wagon with any available heavy vehicle used for the drag load. In the other, more elaborate instrumentation was adopted to simplify interpretation of data. This equipment was permanently mounted in a truck which had a reasonably comfortable cab for observers. This truck carried a large water ballast tank to bring its weight (about 40,000 lb total) to a point where it could supply the total drag load for most tests. The hitch point for the tow cable was arranged so it could be raised or lowered to match attachment at the test vehicle, thus eliminating any vertical component tending to lift or depress the test vehicle. The truck was also equipped with a cable hitch at the rear so that it could be used to tow the test vehicle for vehicle drag testing.

The first problem was to weigh the test vehicle. The codes specify a weight measuring device accurate to ± 2½% of the measured load. This may seem like a pretty liberal allowance. But assume that a scale is guaranteed to ± 0.1%, that is, ± 100 lb on a 100,000 lb scale. If you try to weigh a 10,000-lb axle load a ± 100-lb error becomes ± 1%. And when thrust between the axle on the platform and the axle on the ground increases the ± 100-lb error, when the scale deteriorates slightly, and when the vehicle is a little out of level, it does not take long to start crowding the ± 2½% tolerance.

If a large enough scale is not available and weighing must be done with jacks or highway scales, this limit may be the best one can hope to meet.

The next problem was to impose a load that could be measured "to determine the ability of the vehicle to do useful work beyond that required to move itself on a level test course."

For this, probably everyone uses a tow cable connected through a load-sensing element to a towed load that can be adjusted to resist motion. The point of attachment of this cable to the test vehicle duplicated normal operation.

The towing load was imposed by a heavy vehicle, on either wheels or tracks, equipped with engine, transmission, and brakes. The engine, driven as a compressor from the wheels, provided a range of drag loads through the several transmission gears. These loads were supplemented by the brakes for fine adjustment. If one vehicle did not provide enough resistance, more were added.

Three different force-sensing elements were used in the ERDL demonstration:

1. A hydraulic cylinder-piston assembly.
2. A hydraulically loaded diaphragm.
3. Electric strain gages on a calibrated link.

Even on a concrete test course, tractive force varies too much to permit visual averaging from an indicating meter. And all units record signals from

Fig. 1—Vehicle drag tests were carried out in accordance with the tentative new test code

force-sensing elements on strip charts which must be integrated to determine the average force imposed during the test. This is a time-consuming process. To avoid it, one set of test equipment used in the ERDL operation included an automatic integrator; thus only one slide rule division was required to determine the actual average tow resistance for the run. Such automatic integration saved analysis time.

The code allows ±2½% error in force measurement, which includes errors in the sensing element, recording equipment, and integration. The hydraulic diaphragm unit had a variable-ratio lever system between the tow cable and the diaphragm. This permitted operating the hydraulic system at close to maximum capacity for any force; sizes of hydraulic cylinders and electric strain gage units were varied to accomplish the same result. This improved accuracy with low forces. The automatic integrator reduced the possibility of an inadvertent error in calculation.

Tow resistance can be determined by integration and averaging against the time duration of test, or against distance travelled. Integration against time was used on all three units in the ERDL demonstration where recording charts and one element of the automatic integrator were driven at constant speed. (In the Nebraska test procedure, the strip chart is driven from the ground and integration is against distance.)

The codes specify the minimum length of test as the feet travelled in one half minute (44 times the speed in miles per hour), but not less than 100 ft. This means 100 ft at 2¼ mph, 550 ft at 12½ mph, or more at still higher speeds. The code specifies that the test distance be accurate to ± ½% and timing accurate to ± ½% in one minute.

Three approaches to distance and time measurement were used in the ERDL demonstration: (1) fixed distance, (2) fixed time, and (3) variable distance and time.

With the fixed-distance approach, distance was established by stakes driven into the ground. Time was measured by a stop watch, interconnected so that all instrumentation was started and stopped simultaneously as the test train passed the stakes.

Instrumentation for this approach was the simplest of the three, but the method had two weaknesses. First, the test run had to start and stop at fixed points on the course regardless of how well operation was stabilized. Second, the true distance was not the spacing between the stakes; instead it was the distance covered in the time between starting and stopping the instrumentation. (Additive 6-in. errors at each end of a 200-ft run could add up to the maximum ½% error permitted by the code; and 6-in. travel, at the 4½ mph required to travel 200 ft in one half minute, takes only 1/13 sec.)

Both the fixed-time and the variable-distance-and-time approaches involved use of an odometer wheel for distance measurement. This permitted starting the test as soon as operation was stabilized and stopping as soon as requisite time had elapsed. The odometer wheel was mounted so that it would not jump. It was accurately calibrated and able to register small fractions of a revolution.

The difference between the fixed-time and the variable-distance-and-time approaches was in the

This article . . .

. . . is based on a 6-paper symposium entitled "Report on Reserve Tractive Ability and Vehicle Drag Test Codes and Comparative Demonstration of Test Equipment" presented at the SAE Earthmoving Industry Conference, April 13, 1954. These papers and their authors are:

The Need for a Test Code and Its Objectives
—**H. L. Rittenhouse,** Euclid Division, GMC
—**A. J. Rutherford,** Engineer Research and Development Laboratories, Corps of Engineers, U. S. Army

Discussion of Instrumentation
—**Trevor Davidson,** Bucyrus-Erie Co.

Engineering Research and Development Laboratory Dynamometer Truck
—**F. M. Baumgardner,** Engineer Research and Development Laboratories, Corps of Engineers, U. S. Army
—**J. H. Meier,** Bucyrus-Erie Co.

Goodyear Tire and Rubber Co.'s Dynamometer Truck
—**R. M. MacFarland,** Goodyear Tire and Rubber Co.

Allis-Chalmers Dynamometer Equipment
—**T. A. Haller,** Allis-Chalmers Mfg. Co.

Results and Evaluation of Field Tests
—**P. J. Sperry,** International Harvester Co.
—**P. H. Spennetta,** Caterpillar Tractor Co.
—**D. K. Heiple,** LeTourneau-Westinghouse Co.
—**W. C. Johnson,** Goodyear Tire and Rubber Co.
—**B. L. Fisher,** International Harvester Co.

■

The entire symposium is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

method of recording odometer wheel revolutions.

With fixed-time, rotation was registered on an electro-mechanical counter started and stopped with other recording instruments. In this way, test recording could start or be delayed until operation was stabilized, and could be stopped as desired.

With variable-distance-and-time, rotation was registered by marks on the tractive-force strip chart. With this approach recording could start at any time on an extended length test, and the most satisfactory section of the data could be selected after completion of the run.

Timing was another matter that was not to be considered lightly. Speed regulation of a portable, gasoline generator set was not good enough. Stop watches seem to have a habit of getting out of order. And a governor-controlled DC motor used in the ERDL demonstration failed because its mounting bolts were too tight. Timers can be compared quite easily with a standard 60 cycle unit, and frequent checking was necessary for accurate results.

The codes require that steering be held to a minimum during test runs because of its pronounced effect on performance. Excessive steering was indicated by revolutions of the drive wheels or crawler sprockets on the two sides of the machine.

What Was Found

The field-test evaluation at Ft. Belvoir of the tentative test codes for reserve tractive ability and vehicle drag was made to determine four things:

1. Relative accuracy of equipment and methods in measuring the quantities demanded in the code.
2. Whether or not the accuracy tolerances specified in the code are within reason.
3. Closeness with which repeat measurements on a clay soil course can be made after the course is reworked.
4. A check on the methods of test procedure written into the code.

Inspection of Table 1 and Fig. 2 shows that the measurement methods for reserve tractive force were well within the proposed code limits (plus or minus 2½% or a spread of 5%). The greatest variation occurred during low pulls on the clay course. However, even under these conditions, the spread was considerably under the code limitations.

It is quite possible that a systematic error of calibration was present in one or more of the pieces of pull-measuring equipment that tended to increase the observed spread. Corrections could be made for an error of this nature and the spreads observed would be even smaller. It is felt, however, that systematic errors are bound to be a part of these measurements, and should be included in any expression of expected measurement accuracy.

Engine rpm was measured with accuracy by the several types of equipment. Evidently the accuracy of plus or minus 1% or 2% spread allowed in the code can be readily met.

The 2% spread allowed in the code for the measurement of ground speed was even more easily accomplished.

Travel efficiency, the ratio of the distance the vehicle travels while exerting tractive effort under drawbar load to the distance travelled without drawbar load, was determined by the code procedures. (The test code for reserve tractive ability states that the no-load distance can be determined by self-propelling the vehicle. But it provides an alternate procedure by which the no-load distance can be obtained by pulling or pushing the vehicle.) Data reported by Allis-Chalmers and ERDL were obtained by the self-propelling method, while Goodyear results were obtained by towing the test vehicle.

Travel efficiencies as determined by the alternate method, that of pulling or pushing the test vehicle, did not show consistent differences when compared with the measurements taken by the self-propelled method. The general accuracy of the results appears to be sufficient for the need of these data, which might be termed supplementary to the main objectives of force, speed, and power.

During tests, efforts were made to reprocess the soil course to consistent and similar tractive condi-

Table 1—Summary of Concurrent Measurements

Course	Reserve Force (lb)	Spread of % of Average			
		Reserve Force	Engine Rpm	Ground Speed	% Travel Efficiency
Clay	2000	3.3	0.4	0.6	0.8
Clay	5500	1.9	0.1	0.5	0.7
Concrete (Portland Cement)	9000	0.3 to 0.4	1.0 to 0.1	0.2 to 0.2	0.2 to 0.8
Concrete (Portland Cement)	15,000	2.1	1.8	0	1.0
Spread allowed by code		5.0	2.0	2.0	Not specified

tions for each successive use. Reworking the course was accomplished by first scarifying the surface with a motorized grader and thoroughly pulverizing it to a depth of 8 in. with a pulvamixer. Moisture was then added and the course regraded and compacted with a wobble-wheel roller to uniform surface bearing. Compaction was controlled by taking samples of bearing with a standard Procter needle.

Since the weather was ideal during the test period, the effect of extreme changes in temperature, moisture, or other factors which influence the traction strength of the course could not be analyzed.

The results of checks during and subsequent to the test procedure trials show that a maximum spread of 7% occurred in tractive force during any test where the travel efficiency did not vary over 5%. Later studies by ERDL have shown a variation of ± 1½% of average for repeated tests wherein the ultimate strength of the soil was used.

These results lead us to believe that consistent values may be obtained on fine grained soil courses which are reprocessed with reasonably close control of bearing strength (as measured by Procter needle). However, more experience is needed before this can be accepted as an established fact.

It was not intended to ignore well established practices in conducting the dynamometer work at Fort Belvoir. However, the shortage of time did lead into attempting trial runs before the machines were properly conditioned. This gave results which showed the machines were not yet stabilized for test and emphasized the need for proper break-in and warmup as set down in the test code.

The results of insufficient conditioning were brought out strikingly in the vehicle drag runs made on the crawler tractor. The tracks, when the vehicle was first tested, were quite stiff due to storage for a long period of time and a great deal of power was lost in driving them. Vehicle drag values of over 2000 lb were measured originally. This resistance had been reduced to 1400 to 1500 lb by the time that the official tests began. The vehicle was then blocked up and the tracks run overnight to accomplish further loosening, which reduced resistance to 1100 lb.

When measuring the performance of this type of vehicle, it appears that controlling the condition of the tracks may be equally as important as controlling the soil in which the vehicle is tested.

The test code for reserve tractive ability states that the value to be controlled during the run should be engine speed of the tested vehicle. We quote:

> "While traveling over the measured course during any recorded run, the instantaneous engine or drive output shaft rpm should not vary from the specified speed more than ± 3% and the average speed shall not vary from the specified speed more than ± 1% and the average of engine speeds of the four selected runs shall not vary from the specified speed more than ± ½%."

This clause is designed to provide a test procedure by which a specified vehicle performance can be checked. For this purpose, engine speed is the best single value to control and the procedure is designed to give a practical working tolerance for this check test. The field tests indicate that the closeness of speed control specified can be attained by present test equipment.

An alternate procedure has been written into the code for use when available equipment makes controlling the reserve tractive force more desirable. This is carried out by holding the reserve tractive force of the machine steady and keeping the instantaneous speed at the beginning of the recorded run within 3% of that at the end of the run.

All results presented have been observed figures with no corrections applied. Since there is reason to doubt the accuracy of current correction factors, as applied to diesel engines, we recommend in the code that any test report state observed reserve tractive effort and observed reserve tractive horsepower. If required, corrected reserve tractive horsepower could be shown as corrected in accordance with the standards set forth in the applicable SAE Engine Test Code.

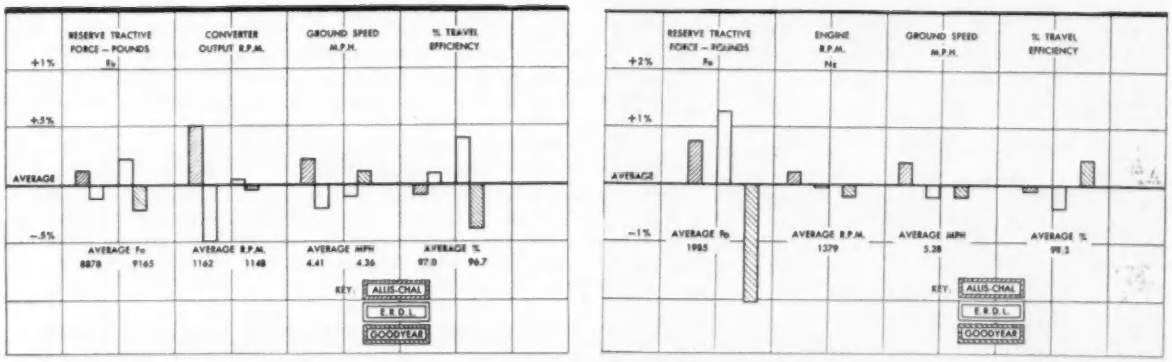


Fig. 2—The accuracy tolerances in the tentative test code for reserve tractive ability were met with all three sets of instrumentation. The figures in the chart at the left are for a crawler tractor operated in fifth gear, the figures in the chart at the right for a wheel tractor operated in third gear

FORGING Forges Far, Far

FORGING has left the village blacksmith far behind. Racing ahead to maintain its leadership in the overall industrial picture, the forging industry today is alive with new trends. Here are just a few:

- Forging blanks are streaming through the rolls of new machines ready for finish forming on the same heat.
- Press forging is rapidly replacing drop forging.
- Both hot- and cold-forging machines are producing parts faster, to closer tolerances, and with less material waste than ever before.

A Forging Blank Every Five Seconds

Today, new machines are squeezing out scale-free forging blanks in less than 5 sec; blanks that are ready for finish forming on the same heat.

All that's necessary in this unskilled operation is that a rectangular blank be placed between two simple roll dies and against a stock gage. (See Fig. 1.) This trips the machine automatically and seconds later out comes an accurately reduced and elongated forging blank.

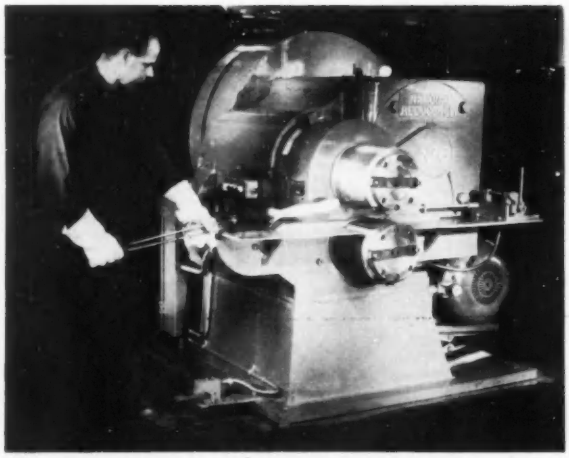


Fig. 1—New machines are squeezing out scale-free forging blanks in less than 5 sec; blanks that are ready for finish forming on the same heat

All the skill, ingenuity, and judgment formerly required to prepare forging blanks now go into this machine and its dies. And properly designed guides, tongs, and stock gages, working in conjunction with the automatic trip, assure fast, accurate feeding and exceptional blank uniformity. What's more, blanks are clean and free of scale. The rolls used in these machines are low in cost and quickly interchangeable, making short runs practical and economical. In the more popular sizes, the machines are portable, enabling them to team up with finish-forming equipment anywhere in a forge shop.

To get an even better idea of what these machines have to offer, let's consider a couple of examples of what they're already doing.

Take the case of an automobile brake-pedal forging. Formerly, a long bar had to be heated, gathered in an upsetting machine, reheated, then finish forged. This resulted in a forging weighing 5 lb 2 oz. With the new forging-blank machine, however, a smaller piece of bar stock is quickly reduce-rolled in two passes, then finish formed on the same heat. The resulting forging weighs only 4 lb 7 oz, a saving of 11 oz of material per forging. The fact that considerably higher production rates are being achieved adds still more icing to the cake.

In still another case, one of these machines recently replaced a hammer in one of the largest automotive forge shops in this country. It permitted reducing the operating crew from four to three men, increased output from 575 to 900 forgings per 8-hr shift, and saved 1 lb of steel on each steering bell crank forging made.

Drop Forging Getting Its Walking Papers

Press forging is rapidly replacing drop forging. Some forge shops report four times greater output, unit for unit, as a result of swinging to presses.

Ahead of Village Smithy

Robert G. Friedman, The National Machinery Co.

Based on paper "Trends in Modern Forging" presented at SAE National Passenger-Car, Body, and Materials Meeting, Detroit, March 3, 1954.

Further, the age-old requirement of artisanship in drop forging has now been removed . . . and replaced by know-how in modern die layout and press design. Press operators quickly become experts, and forgings are no longer scrapped for want of skill.

Most press forgings are being made with only two or three blows. Mechanical ejection allows designers of forgings to reduce draft, cutting material costs and machining time.

Still other reasons are behind this swing to presses. Press dies, subject only to squeeze rather than impact, can be inserted with longer lasting die steels. Die life is further increased by virtue of the shortness of contact time and immediate ejection of the forging. What's more, forging presses run quietly and free from vibration. They require only comparatively inexpensive foundations which do not demand periodic repair.

Squeezing Jet Blades to Finish Dimensions

Today, presses are precision-forging jet blades and buckets to finish tolerances. Many military ordnance forgings, too, are being hot-extruded to finish dimensions. (See May, 1953, SAE Journal, pp. 69–70.)

New Machines Work Like Demons

High-speed cold-forging machines are garnering more and more jobs from screw machines . . . and for good reasons. For one thing, these machines are able to produce work of far greater accuracy and much better finish. For another, they spit out parts faster and with far less material waste.

But cold-forging machines don't have a corner on the new job market. Hot-forging machines are landing new jobs too, for much the same reasons.

A radically new hot-forging machine, for example, is producing 1-in. nuts at the rate of 85 per min, 1½-in. nuts at the rate of 75 per min. Now, in the past, the industry was content with a scrap loss of 50% on such large hot-forged hex nuts, 30% on square nuts. With this new hot nut former, however, the loss is only 8 to 10%—a substantial saving indeed.

As for cold-forging machines, multi-station progressive headers are now producing close-tolerance parts 7 to 15 times faster than by the old machining methods. What's more, material waste is being reduced by up to 50%.

An automobile distributor cap insert, for example, is being made at the rate of 90 per min in a 5/16-in., 2-die progressive header. (Twelve screw machines were formerly assigned to this job.)

And thanks to a progress header extruder, a completely hollow rivet has become commercially practical. (See May, 1953, SAE Journal, pp. 69–70.)

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Seven Brazing Methods That

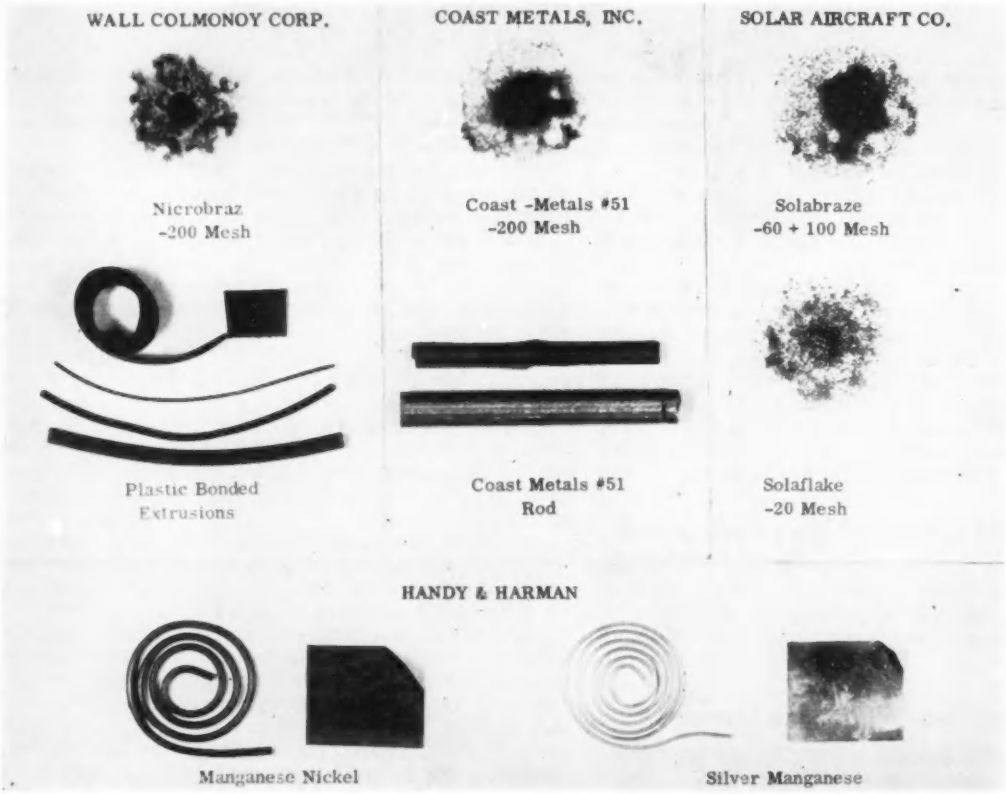
JET PROPULSION has catapulted high-temperature brazing into a position of importance as a manufacturing process. Brazing processes for "hot parts" (components exposed to high temperatures where corrosion resistance is important) are coming into their own in the aircraft industry. They bid fair to do a job in other industrial applications too.

High-temperature brazing is a metallurgical joining process. A molten filler metal is used having a melting point above 1600 F, but below that of the base metal. Diffusion between filler metal and base metal must occur.

Future automotive, aircraft, and missile designs will rely heavily on this unique metal-joining process. Complex and multi-component sheet metal parts lend themselves to assembly by this technique. High-strength joints can be made between cast and sheet metal, dissimilar metals, widely dissimilar metal thicknesses, and other unconventional combinations.

High-temperature brazing encompasses a wide field of applications—powdered metal blades, carbides, and metal-ceramic compositions. The specific brazing materials and examples that follow cover assemblies made of wrought and cast materials.

Shown below are some of the brazing materials discussed and the forms in which they are available.



Pay Off for "Hot Parts"

G. D. Cremer, F. J. Filippi, and R. S. Mueller

Research Division, Solar Aircraft Co.

Based on paper "High-Temperature Brazing Operations" presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 1, 1953. This paper will be printed in full in 1954 SAE Transactions. It also is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

1. Nickel Brazing Alloys

Coast Metals, Inc., of Little Ferry, N. J., has developed a series of brazing alloys containing a minimum of 85% nickel, 2 to 3% boron, 3 to 5% silicon. One alloy, Coast No. 53, contains in addition about 7% chromium.

Other facts about these alloys are:

- Flow point—1850 F.
- Recommended furnace temperature—1900 to 2050 F.
- Braze using flux or protective atmosphere.
- Material available as powder or cast rod.

Superweld Corp. has done outstanding development work in adapting its copper brazing facilities to accommodate the requirements of these high-temperature, corrosion-resistant brazing alloys. The illustration at right shows the discharge end of Superweld's completely conveyorized 105-ft furnace.

The unit is rated at 300 kw and can process over

one-half ton of parts per hr. Stainless and high alloy steel assemblies have been brazed in this equipment using any of several Coast Metal alloys.

2. Silver-Manganese Brazing Alloys

Handy and Harman, of New York City, produce an alloy composed of 85% Ag and 15% Mn. It is a solid solution type alloy that's tough and ductile. The material has a melting point of 1750 F, a flow point of 1760 F, and requires a furnace temperature of 1850 to 1950 F. It is available in wire or strip form.

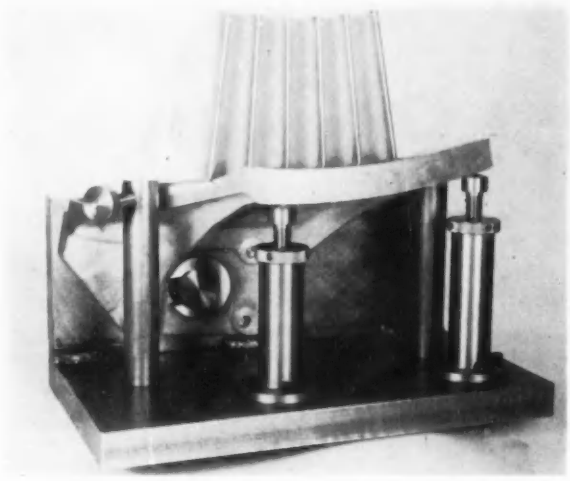
When brazing with this material, an "H" flux should be used, or pure hydrogen with a –80 F dewpoint.

Silver-manganese brazing material can be used for joining stainless steel and high alloy parts subjected to temperatures up to about 1300 F.

Shown on the top of p. 72 is a turbine stator shroud vane assembly, jigged for silver-manganese brazing in dry hydrogen. After brazing, tolerances between blade tips and flanges were well within the ± 0.005 in. specified. This high degree of precision illustrates a salient feature characteristic of well-engineered brazing application.

Other successful brazing applications using Ag-Mn include attachment of Inconel fuel line fittings, joining of Stellite valve seats to stainless valve bodies, and applying cemented carbide tool tips to steel shanks for hot machining operations.

Please Turn Page



3. Manganese-Nickel Brazing Alloys

Handy & Harman also produces a 68% Mn-32% Ni brazing alloy. It is of the solid solution type alloy and is fairly tough. This alloy has a melting point of 1850 F, and a flow point of 1860 F. Brazing conditions are similar to those for the silver-manganese alloy. The Mn-Ni alloy is subject to scaling at elevated temperatures. It is available as wire or powder. Operating temperature for Mn-Ni brazes range up to about 1500 F.

This alloy has a potential use in liquid-cooled nuclear reactors since it is not attacked by liquid sodium.

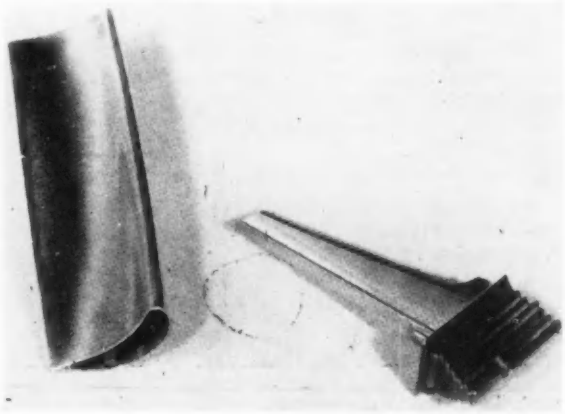
4. Palladium-Silver Brazing Alloy

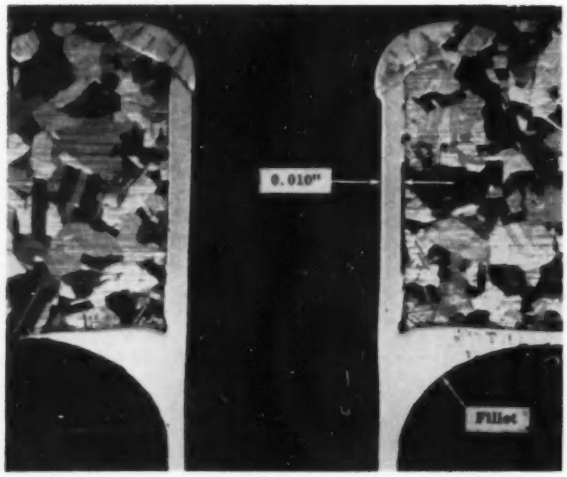
This material is produced by the Mond Nickel Co., Ltd., of London, and is distributed in the United States by the American Platinum Works, Newark, N. J.

This alloy is composed of 75% Ag-20% Pd-5% Mn. It is a tough, ductile alloy with a brazing temperature of 2050 F, and is available in wire and strip. Limited information is available on this alloy, known as S.P.M. 1.

S.P.M. 2 is a similar high-temperature brazing alloy. Its recommended brazing temperature is 2240 F.

The photograph here shows a "Nimonic 80" hollow gas turbine blade. The airfoil sheath is brazed with this material over a large shear area to the root section.





5. Palladium-Nickel Brazing Alloy

Palladium-nickel is an experimental alloy available from the Metallurgy Division of the Oak Ridge National Laboratory at Oak Ridge, Tenn. It contains 60% Pd and 40% Ni. The material is a solid solution type. It's tough and ductile. It has a flow point of 2300 F, a brazing temperature of 2350 F.

The accompanying photomicrograph is of a 10-mil wall, Type 316 stainless steel tubing attached to a $\frac{1}{8}$-in. thick, Type 304 stainless steel head by cone-arc welding. Palladium-nickel brazing alloy was flowed around the opposite face to improve the strength properties of the welded assembly. It's pretty evident that the braze has substantially diffused with the base metal.

6. Solabraze

Solar Aircraft Co., of San Diego, Calif., currently is developing a family of alloys to meet specific classes of high-temperature brazing applications. They range in composition from 60 to 85% nickel, up to 20% chromium, up to 30% manganese, ½ to 5% silicon, 0 to 3% boron, together with varying amounts of iron and molybdenum.

These materials have a flow point from 1750 to 2000 F. They are presently available in powder and cast rod form. They can be brazed using a flux or with pure, dry hydrogen.

Solar developed these brazing alloys as a solution to the problems of attaching manifold flanges. Fig. A is representative of an actual brazing operation. A stable, refractory flux is necessary to permit braze metal flow in air at 2000 F. Automatic time-temperature programming control is used for the 2½ min. heating cycle.

Fig. B shows a half manifold set arranged on an inspection jig. Both AISI 347 cast flanges as well as AISI 321 sheet metal flanges are used in this brazed assembly. After brazing, the manifolds are ceramic-coated inside and out by the Solarmic process. This accounts for the high reflectivity in the photograph.

The photomicrograph in Fig. C is of a sectioned and etched sheet-metal flange joint after 500 hr dynamic cycling to 1500 F. The massive braze metal measures about 0.010 in. in radial thickness. Diffusion with the base metal is indicated by the dark parallel bands within the 321 base metal.

Fig. A

A dense braze structure is evident. It consists of two well-defined phases. A few scattered voids are typical of massive brazes made using a flux rather than a pure, dry hydrogen atmosphere, for example.

Afterburner fuel spray nozzles are another application where Solabraze has been used. These Type 321 stainless steel assemblies inject additional fuel directly into the jet engine exhaust stream. The orifice and sleeve are high-temperature brazed to a heavy walled tube in one operation. Another outstanding field of application for high-temperature brazing is turning and straightening vane assemblies for use in turbojet engines.

A useful characteristic of the brazing process is of great significance in large, multicomponent parts. Overall distortion during brazing can be maintained within remarkably small limits. It is not unreasonable, for example, to maintain flatness over a 2-ft diameter within 0.030 in.

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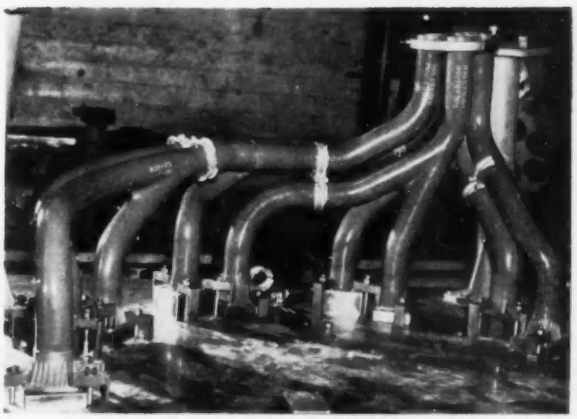


Fig. B

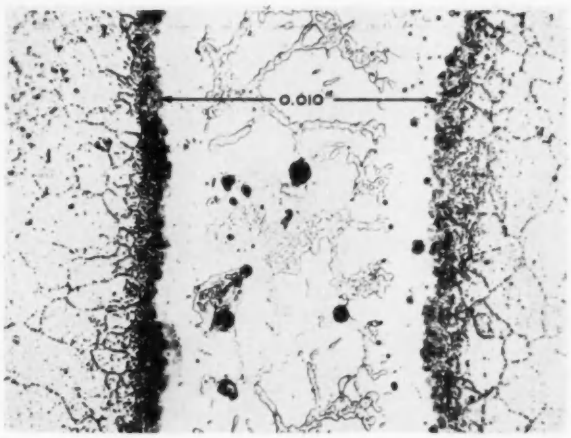


Fig. C

7. Nicrobraz

The Wall Colmonoy Corp., of Detroit, produces a hard, highly corrosion-resistant alloy known as Nicrobraz. It meets SAE Aeronautical Material Specification 4775. Nominal alloying composition of this nickel-base brazing alloy is: 4% silicon, 16.5% chromium, 4% iron, 3.8% boron, and 1% carbon.

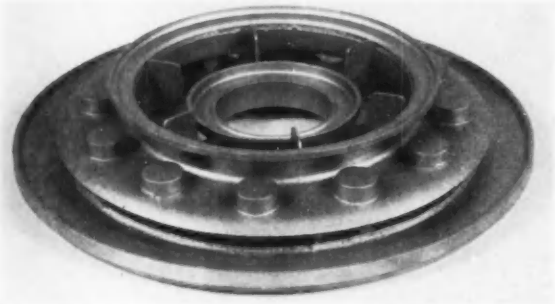
The material has a flow point of 1930 F and a brazing temperature range of 1950 to 2150 F.

Nicrobraz has been extensively used from the beginning of applied development work in corrosion-resistant, high-temperature brazing. It was probably the first commercially available brazing alloy to exploit another rather unique characteristic. Nicrobrazed joints can be made which exhibit useful strengths at temperatures above the melting point of the massive brazing alloy itself. This significant fact has an interesting explanation.

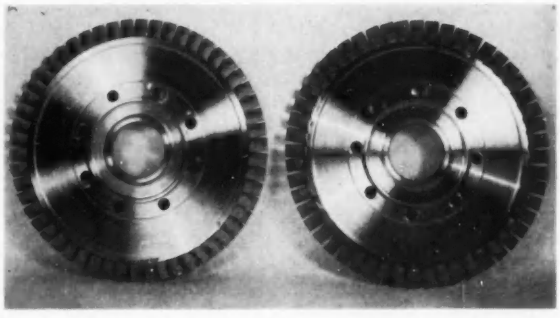
With relatively tight-fitting brazed joints, the effects due to atomic diffusion at the brazing temperature occur very rapidly. For example, in the case of stainless steel brazed with Nicrobraz, mutual diffusion between the base metal and braze metal produces an entirely new series of alloys in, and adjacent to, the joint.

A Nicrobraz composition (with boron, carbon, and silicon removed) would melt at about 2250 F. Diffusion during brazing, or by subsequent heat treating, simply reduces the concentration of these critical elements. That raises the "remelt" temperature of the joint.

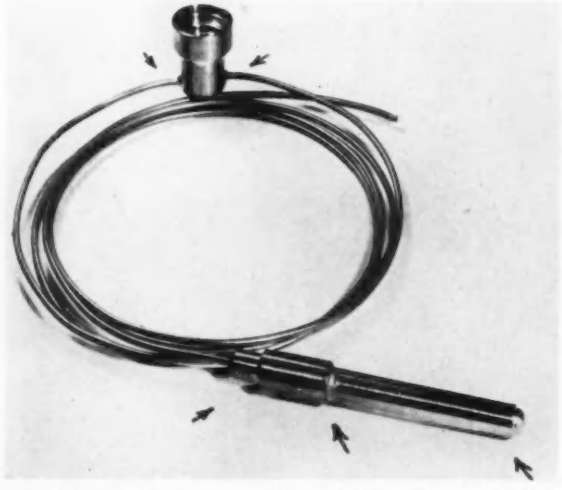
In addition to this characteristic of Nicrobraz, its outstanding oxidation and corrosion resistance properties are important. Nicrobraz is being used by a number of manufacturers to produce brazed assemblies. A few of them are shown below.



1. This heat shield consists of 23 stainless steel parts. Fixturing is minimized by using spot and tack welds. All joints are brazed with Nicrobraz in one furnace operation. Satisfactory service at 1000 F is reported.



2. This is an outstanding application of Nicrobraz. It is a 12-in. diameter, AISI 431 compressor rotor wheel, designed to operate at 12,000 rpm and 500 F, maximum. Blades were attached to the disc rim in a dry hydrogen, furnace brazing process.



3. This rather unusual application is a mercury control element in Type 437 stainless steel. Because Nicrobraz resists mercury attack at temperatures up to 1700 F, it offers interesting possibilities in the high-temperature instrumentation field.

4. This combustion chamber is a beautifully engineered assembly. It is a heavy-duty unit which functions as a turbojet starting mechanism. Construction details are not available; however, commercial production of the unit is reported.

Helpful Hints on . . .

PRODUCTION CONTROL

W. Hoth, Evinrude Motor Division, Outboard Marine & Mfg. Co.

Based on secretary's report of Panel on Production Control held as part of the Production Forum at the SAE National Tractor Meeting, Milwaukee, Sept. 14, 1953.

Panel response to questions brought the following suggestions on:

Inventory and Parts Control

1. Rough material should be checked in and disbursed in a common unit.

2. Stock in process should be considered as stock on hand in stores until the product is completed. When material is received it can be disbursed directly to the line. Stock room records can be used for location purposes.

3. Rough material should be kept separate from finished parts and the machine shop should be considered as another vendor. Final inspection should keep a record of all good pieces and their count should be double-checked by finished stores.

4. The number of times an inventory should be checked depends on the size of the part and how much time the individual company wants to put on checking parts. In most cases, small parts should be checked at least twice a year and large parts at least once a year. If discrepancies occur or engineering changes affect a part, a recheck should be made at once.

5. Divisional expeditors should keep in close contact with parts in process and be able to report the progress of any job. (One plant has a central control station to which all divisional expeditors report on rush jobs. A two-way radio is set up between lift trucks and this station to expedite the movement of stock.)

6. A monthly or weekly scrap report helps to keep all departments scrap-conscious. A closer check may be made by having the department foreman sign all scrap tickets and have him check on the reason for scrap. (A bonus system for supervisors is being used in many plants, with the supervisor's bonus depending on the scrap that is charged against his department. A bonus system for the workers also is sometimes used. Then a record has to be kept on the daily quality of each man's work.)

Scheduling for Customers and Subcontractors

1. It is well to analyze customer requirements in advance and provide material for an early delivery. . . . Scheduling production slightly under factory capacity to allow for fast delivery when necessary is good practice. . . So is giving your customer a quarterly schedule. Then he can appreciate your position when requesting a fast delivery. . . Special consideration should be given to all regular customers' orders by anticipating their future requirements and ordering stock in advance of their orders.

2. If it is necessary to send out parts to subcontractors to relieve an over-schedule, careful consideration must be given to the subcontractors' ability and equipment. Tooling cost must also be considered. Production Control should handle the scheduling of these parts, so no time is lost.

3. To make an IBM machine practical, there must be a high volume of repetitious paper work. It can be used on checks, accounts payable and receivable, posting of requirements, shortage sheets, individual performance records, purchase orders, schedules, stock status, and requisitions.

(The full report on which this article is based, together with the secretaries' reports on the other seven panels of this Production Forum, are available from SAE Special Publications Department, 29 West 39th Street, New York 18, N. Y., as SP-303. Price: $1.50 to members, $3.00 to nonmembers.)

Panel Members

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White Motor Co.

W. Hoth, Secretary
Outboard Marine and Mfg. Co.

P. A. Miller
Leece-Neville Co.

R. F. Luckus
Chain Belt Co.

Harvey Taylor
Heil Co.

Del Hanson
J. I. Case Co.

L. Schmidt
Allis-Chalmers Mfg. Co.

Russell Wetzel
Bendix Westinghouse

Memo to Designers–

Better Turbojet

This article is based on the following papers and discussion:

"Factors Against the Use of Turbojet Inlet Screens," by William R. Travers,
General Electric Co.

"Retractable Air Inlet Screens for Aircraft Gas Turbines," by J. E. DeRemer,
Smith-Morris Co.

"Inlet Protection for Aircraft Gas Turbine Engines," by R. S. Litton,
Air Induction Systems, Powerplant Laboratory, Wright Air Development Center.

Discussion by R. R. Higginbotham,
Republic Aviation Corp.

Discussion by Ed Rock,
Boeing Airplane Co.

Report of oral discussion by O. P. Prachar,
Allison Division, GMC.

This material was presented at the SAE National Aeronautic Meeting, New York City, April 15, 1954.

Individual papers are available in full in multilithographed form from SAE Special Publications Department for 35¢ each to members, 60¢ each to nonmembers.

WHEN the Air Force reports that it is spending over one million dollars a month just to repair jet-engine compressors damaged by foreign objects, it seems that drastic action is needed.

Unfortunately, there is strong disagreement as to just *what* should be done about it.

Some of the controversy centers around answers to the following questions:

1. Should the screens be fixed or retractable?
2. Should the screens be mounted on the engine or in the airframe duct?
3. Should the screens be permanently mounted or should they be ground removable?
4. What size of screening should be used?

Back in 1945, when the USAF first began to use jet aircraft, the simplest answer seemed to be merely to require that fixed inlet screens be installed on all axial-flow jet engines—a procedure the Air Force tried, sometimes with tragic consequences.

For example, in June, 1951, eight F-84's crashed near Richmond, Ind., because of inlet screen icing. A technical order was immediately issued calling for the removal of fixed inlet screens from certain types of aircraft. The result was a definite upward trend in the rate of accidents caused by compressor failure. Moreover, the removal of the fixed inlet screens did not completely eliminate icing on these aircraft, since their engines were not anti-iced.

In April, 1952, another technical order was issued. This time, the installation of fixed screens was made optional. As a result, most jet engines were again equipped with inlet screens. From this time on, there was a general lowering of the rate of accidents caused by compressor failures. This downward trend was also aided by a general stiffening of airfield housekeeping requirements and revisions of operational techniques.

Although, in this example, screens did lower the rate of foreign object damage, in other cases there is no apparent difference between using screens and not using them. This was found to be true in an Air Force survey made during two months of 1953. During this time, many aircraft had retractable screens installed. The overall rate of foreign

Inlet Screens Are Badly Needed

object damage was 17% for the total engines removed. A breakdown, however, shows no appreciable difference between fixed screens, ground screens, retractable screens, and no screens at all, as far as foreign object damage was concerned.

In some cases, failure of light, fixed screens has caused more compressor damage than would have occurred if no screens had been installed.

In other words, although we have irrefutable evidence that axial-flow gas turbines can be severely damaged—and even blow up—when foreign objects

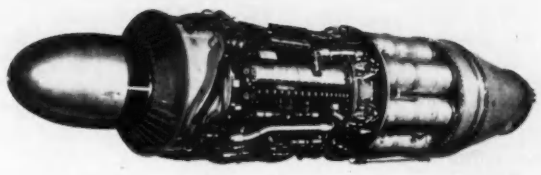


Fig. 1—Turbojet engine with fixed inlet screen (from Travers)

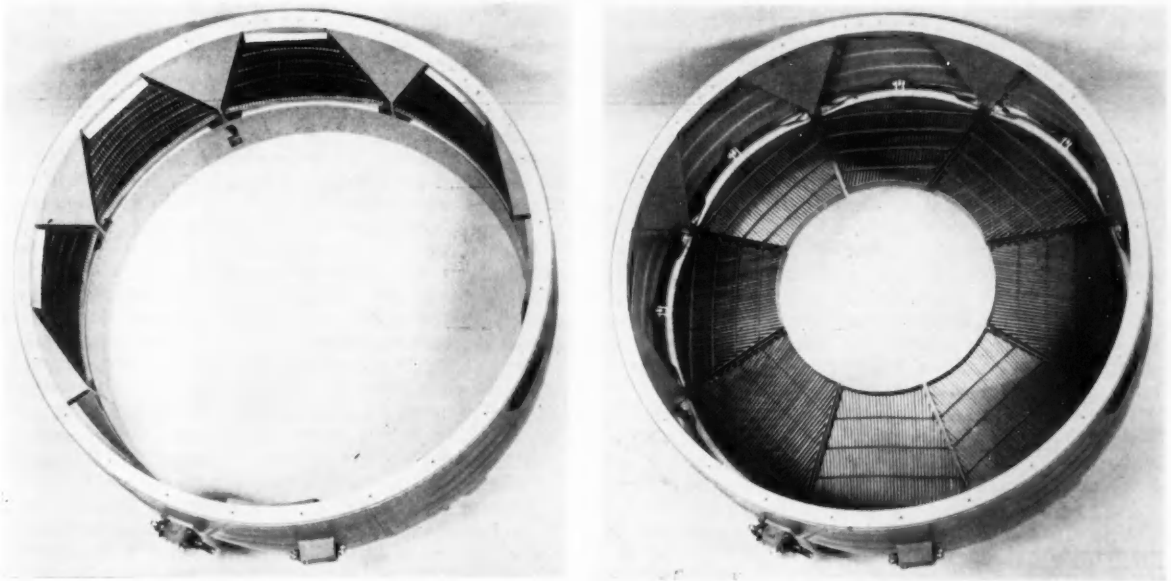


Fig. 2—Retractable screen for J-71 engine—left: screens retracted; right: screens extended (from DeRemer)

enter the engine inlet, engineers differ greatly as to what to do about it.

Fixed versus Retractable

Fixed screens (Fig. 1) were first used on turbine engines to prevent the admission of foreign objects into the gas turbine air intake. These screens were light, had no mechanical parts to get out of kilter, and were relatively cheap and simple to make. Unfortunately, they were found to cause a 1–3% loss in thrust. Since they are always in place, even during periods when they are not needed, this means there is a continuous loss in power.

This lower performance is undesirable, but it was not nearly so serious as another difficulty that was soon experienced. These screens were found to ice over easily. Generally, the consequence is engine failure and possible disaster, as in the case of the F-84's already mentioned.

Although several anti-icing systems were developed, none appeared attractive except the A.V. Roe alcohol system used in the CF-100 and an interim system used in the F-84. Even these systems fell short of Air Force requirements.

In 1947, the USAF started the development of retractable screens (Fig. 2) that, it was hoped, would eliminate this icing hazard. These screens cover the inlet area only when they are needed. At other times they can be folded out of the way, so that ice forming on them will not block the inlet, and reducing the power loss to an almost negligible point.

Unfortunately, present designs appear not to have lived up to expectations completely—and they have disadvantages of their own.

For instance, on a typical turbojet engine the inlet screen mechanism may be 2¼% of the total powerplant weight or 40–80 lb.

Then there is the problem of how the inlet screen retraction should be controlled. If we say that the screens should be retracted when signaled by an icing anticipator, we are adding complex gadgetry and controls to the airplane. Another system could be to have the pilot retract the screen mechanism by flipping a switch at some prescribed amount of time after take-off to achieve the kind of engine performance we would like to have on the mission. This, however, gives the pilot more to do, more gadgetry in the cockpit, and another item that may not be operated in every case according to plan.

It also appears that the retractable inlet screen is far from complete insurance against icing troubles (Fig. 3). In the first place, icing can occur during take-off, which is the period when the screens are needed most. Ice can also form during the landing approach, when the screens are likely to be extended. The ice buildup may occur so rapidly that, by the time it is discovered and retraction is attempted, there may not be enough hydraulic pressure in the system to actuate the mechanism.

How well do these screens—fixed and retractable—do the job they were designed for? The record is not too good. USAF records show that screens lowered the rate of foreign object damage in some cases, while in other operations there was no apparent difference between the use of screens and no screens at all. In some instances, failure of a light, fixed screen caused more compressor damage than would have been caused had no screen been installed at all.

Moreover, retractable screens showed no conclusive reduction in the rate of foreign object damage. Conclusions as to the effectiveness of these installations are not possible, however, because the methods established for the operation of retractable screens on the aircraft covered in the records could not be determined from the data presented.

Thus, it appears that, although the retractable screen has possibilities for eliminating the damage to turbine engines from objects entering the inlet, the satisfactory model is yet to be designed.

What qualities should the retractable inlet screen have? Some of them are:

1. Rockbottom power loss, both while extended and while retracted.
2. Considerably lower weight.
3. Simple, reliable retracting mechanism.
4. Screen must not allow the foreign objects collected while it was extended to be dumped into the inlet when the screen is being retracted.
5. Icing hazard must be completely eliminated.

Engine Mounting versus Duct Mounting

Obviously, this problem has meaning only where there is a duct to work with, such as in the case of submerged installations in fighters. In the nacelle or wing installation—of which there are a good many—the screen almost always must be at the face of the engine, since there is no other place to locate it.

The first retractable screens developed by the USAF were engine mounted. This worked well, for the circular shape of the engine inlet lent itself to inlet screens much better than the unsymmetrical shape apt to be found in airframe ducts. Also, the screen could be designed to be compatible with the engine, and could be applied to all installations of that engine.

Some people began to criticize the engine-mounted, retractable screen, however, on the grounds that it is heavy and causes too high a thrust loss, since it is generally located in the highest velocity sector of the duct system.

On the surface, putting the retractable screen in the airframe duct appears attractive. Where space is available in the lowest velocity sector of the duct, a lighter screen with a lower pressure loss than an engine-mounted screen should be possible. The space needed for actuation may, however, already be occupied by electronic or armament equipment. Since the screen is actuated as a whole rather than in sectors, actuator units must be fairly large.

Duct screens also have the advantage that only one screen assembly is required per installation. Since several spare engines must generally be kept on hand for each plane, this means that fewer screens are needed than when the screens are engine mounted. Obviously, in the latter case, each engine would carry its own screen.

Duct screens also have their disadvantages. For instance, objects can be left in the space between the engine and the screen. They might later be sucked into the engine, causing its loss.

A more serious criticism of the duct screen is that it is necessary to design, develop, and produce a screen for each airframe to which it is to be applied. When one engine model is used on many different planes, this means much duplication of work and

more screens are needed, compared to the engine-mounted screen, where one screen design applies for all installations of that engine.

In submerged fighter installations where performance is extremely critical, comparative studies of the engine-mounted versus the duct screen should be made, and the penalties weighed against the gain in performance. Current designs indicate that, for a favorable installation, duct screens would weigh about 50 lb, against an engine-mounted screen weight of 100 lb, and reduce overall installed thrust loss by about ½–1%.

Permanent versus Ground Removable

Ground-removable screens seem attractive because it doesn't seem right to haul around the sky a gadget that serves most of its function on the ground. As a matter of fact, ground-removable screens have been made with a mesh size down to No. 16. Such screens are capable of protecting the compressor from all damage except sand abrasion.

Serious disadvantages exist against these screens, which have limited their use so far. These include:

1. Ground removable screens cannot completely eliminate damage from foreign objects, since operational requirements generally necessitate the removal of such screens before taxiing. Thus, they are not in place to prevent the intake of foreign objects during take-off or in combat, when the danger still exists.

2. Men and equipment are required to install and remove the screens, which makes the use of such screens undesirable in operations of any size. If protection is desired during all ground operations up to the point of take-off and at the end of the landing roll, things get very complicated and dangerous. Of course, no protection is still provided for take-off, landing, and during combat.

3. Screens are becoming monstrous in size and shape because they must be large enough to prevent choking at the inlet. Ground crews are reported to be showing some reluctance to using such large screens. There is also the possibility of leaving things down stream from the screen, as with internal duct screens.

Until most of these disadvantages are overcome, such screens seem to have but limited value, being useful only when airborne screens can't be used because of performance or space reasons.

Size of Screens

Inlet screen spacing is generally compromised at ¼ in., but there is certainly no general agreement that this is the optimum mesh to use. Although the ¼-in. spacing is capable of screening objects capable of causing immediate compressor failure, it does not eliminate all compressor damage.

Finer mesh would, of course, protect against smaller objects, but it causes a greater loss of thrust.

To try to find out what actually is causing the trouble, Republic once equipped an F-84G with fine screens over the main nose inlet and the side inlet doors. These wire cloth screens of No. 12 mesh (more than three times as fine as the ¼-in. screens) were pocketed inside the duct inlets in such a way as to retain any material caught. The airplane was taxied all over the airport at all speeds and under all sorts of conditions. It was taxied behind other

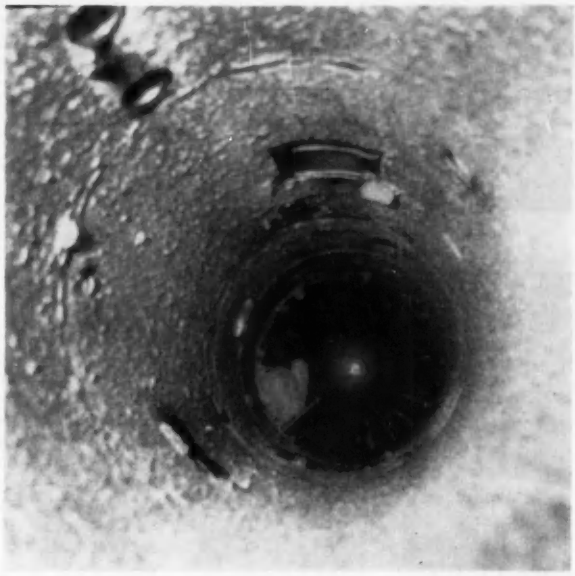


Fig. 3—Retractable screens can become iced. This view shows a single segment that collected ice and was gradually forced into blocking the compressor inlet by the air pressure and held there, despite the actuating pressure of the mechanism. Such a blockage can cause turbojet malfunction (from Travers)

jet aircraft, taxied at full throttle through gravel deliberately spread on the runway and even had gravel thrown by hand into the air ahead of the main intake.

No material coarse enough to be caught by a 12-mesh screen was ever picked up from the ground and no material was thrown into either side inlet by the nose wheel. Pebbles thrown by hand into the air 4 in. ahead of the intake were not drawn in. The only time any objects were caught by the screen was when the engine was run up in the wake of another jet aircraft. Only five pebbles were found in the screens during the entire series of tests, one following a taxi back to the ramp behind another aircraft and four after a simulated formation take-off. All five were small enough to pass through a ¼-in. screen. The engine suffered no compressor nicks during these tests, although airplanes going through acceptance tests with ¼-in. screens at the same time and place were experiencing a foreign object damage rate of about 11%.

These tests indicate that a considerable percentage of compressor nicks are caused by material of a size between 12 mesh and ¼ in., since this engine suffered no damage from material less than 12 mesh, while the damaging effect of material less than ¼ in. is well established. The tests also show that foreign object damage could be materially reduced by avoiding any operation of jet aircraft in the wake of another.

Convinced of the inadequacy of ¼-in. screens, as regards ground protection, Republic made it a rule on all production F-84F aircraft to conduct ground operations with the ¼-in. retractable duct screens retracted and with 12-mesh ground-removable screens slipped on over the nose and side inlets. This practice has resulted in a significant reduction in foreign object damage, compared to F-84G experience using ¼-in. fixed screens.

About SAE

Fawick

Acheson

Minshall

Kyes

Trichel

Duncan

Raymond

Hill

Gibbons

Kalchthaler

THOMAS L. FAWICK, chairman of the board of Federal Fawick Corp., Cleveland, has also been elected president and will now hold both titles. Selection of Fawick as president is one of the steps undertaken in a realignment of management responsibilities following the sale last June of the Federal Motor Truck Division and its manufacturing plant in Detroit to Mast-Foos Mfg. Co. of Detroit.

HOWARD A. ACHESON, president Acheson Colloids Corp., Port Huron, Mich., has been elected president of Gredag, Inc., Niagara Falls, N. Y. Gredag is a subsidiary of Acheson Industries, Inc.

ROBERT J. MINSHALL, former president of the Pesco Products Division of Borg-Warner Corp., Chicago, has been named chairman of the supervisory board and director of research and development for the division. Appointing Minshall to head Pesco's research and development heralds a future expansion of the program.

ROGER M. KYES will now serve as a group executive in charge of GMC's Dayton and Household Appliance Divisions and of the GMC Truck & Coach Division at Pontiac, Mich. He has been elected a member of the board of directors of GMC and of the Operations Policy Committee of the company.

Kyes joined GMC in 1948. He served as executive in charge of the procurement and schedules staff and as assistant general manager and later as general manager of the GMC Truck & Coach Division for more than two years prior to his appointment as Deputy Secretary of Defense in January, '53. He resigned as Deputy Secretary of Defense May 1.

G. W. TRICHEL has been elected executive vice-president and general manager of the Amplex Division of Chrysler Corp. He was vice-president and director of Fargo Motor Corp., Chrysler Corp., Detroit.

TURNER A. DUNCAN is now vice-president and general manager of the Turner Mfg. Co., Statesville, N. C. He is responsible for all manufacturing and for coordination and manufacture of sales, as well as coordination of all departments of the business. He is also responsible for the development of new products within and without the farm implement business. Duncan was formerly vice-president of ACF-Brill Motors Co., Philadelphia.

LEONARD RAYMOND is now chief automotive engineer, of Socony-Vacuum Oil Co.'s automotive division, New York. Raymond was formerly assistant chief engineer of the division.

E. B. HILL, vice-president, Gar Wood Industries, Wayne, Mich., is now director of sales, advertising and export for all corporation products. Division sales managers, who formerly headquartered at plants, will now report directly to Hill. Gar Wood's reorganization of its sales activities under Hill's direction, follows the completion of a new product development and improvement program.

CARL W. KALCHTHALER has been appointed as chief engineer for the Hyatt Bearings Division of GMC,

Hunt

Olek

Williams

McFadden

Garlick

Kaye

Members . . .

Nutt

Kinzel

Mackenzie

Douglas

Bradford

Ireland

Harrison, N. J. He was assistant to the general sales manager in the division. Kalchthaler succeeds **H. RALSTON GIBBONS** who has been named technical assistant to the general manager.

WILLIAM T. HUNT has been assigned to the post of chief metallurgist for the New Process Gear Corp., Syracuse, N. Y. Hunt was previously chief metallurgist at the Chrysler tank plant at Newark, Delaware.

NICHOLAS OLEK has been appointed sales representative for Johns-Manville Friction Materials in the Chicago-Midwest area. Prior to joining Johns-Manville, Olek was associated with the Metallic Friction Material Co., Cleveland.

RALPH E. WILLIAMS has been promoted from assistant works manager to works manager at the DeLaval Separator Co. in Poughkeepsie, N. Y.

DAVID B. McFADDEN has become regional service manager in the Texas regional office of The White Motor Co., Dallas. Prior to joining White, McFadden was transportation coordinator for the Humble Oil & Refining Co., Houston.

MARK J. GARLICK, JR. has been appointed assistant chief engineer, Pontiac Motor Division of GMC. He succeeds **R. R. HUTCHISON** who has retired (See August Journal, p. 94). He was experimental engineer for Pontiac.

H. E. KAYE, assistant chief engineer, Rollway Bearing Co., Inc., Syracuse, N. Y., has been named chairman for the next year of the Roller Bearing Engineering Committee, Anti-Friction Bearing Manufacturers Association. Kaye's committee will administer an industry-wide program to standardize the limits, capacities, and other engineering characteristics of anti-friction bearings.

HAROLD NUTT has been promoted to vice-president and general manager of the Borg & Beck Division of Borg-Warner Corp., in Chicago. He previously was vice-president and assistant general manager. **RICHARD L. SMIRL** has been named director of engineering of Borg & Beck. He previously was assistant director of engineering.

AUGUSTUS B. KINZEL has been appointed as director of research, Union Carbide and Carbon Corp., N. Y. He will be responsible for the administration and coordination of the research activities of all divisions of Union Carbide. Kinzel is president of Union Carbide & Carbon's Research Laboratories, Inc.

KENNETH G. MACKENZIE has been elected to honorary membership in the American Society for Testing Materials, recognizing especially meritorious service in both technical and administrative activities of the society. Mackenzie retired last March from The Texas Company where he was assistant to the vice-president in charge of the refining department.

EARL M. DOUGLAS has been appointed vice-president and is now in charge of all manufacturing operations for The Studebaker Corp. His headquarters are in Sotuh Bend, Ind. He was general manager of the company's Los Angeles plant.

C. I. BRADFORD, vice-president and director of operations of Rem-Cru Titanium, Inc., Midland, Pa., has been appointed president of the company and a member of the board.

WILLIAM E. IRELAND, vice-president of B. F. Goodrich in Canada, has been elected a director of the company. Ireland, formerly vice-president, tire sales, has also been appointed as vice-president-sales, with responsibility for all sales divisions of the Canadian company.

P. H. SCHWEITZER recently returned to The Pennsylvania State University, where he is professor of engineering research. Dr. Schweitzer had spent nine months studying engines in twelve European countries, with Graz, Austria, his base of operations.

R. P. DINSMORE, vice-president in charge of research and development for The Goodyear Tire & Rubber Co., has received a 40-year service pin from **P. W. LITCHFIELD.** The diamond-studded pin was presented at special ceremonies attended by some 1,000 of Dr. Dinsmore's associates.

LOUIS F. POLK, chairman and president of the board, The Sheffield Corp., Dayton, Ohio, has been nominated to serve as a director-at-large of the American Society of Mechanical Engineers.

CARL R. CANFIELD is now manager, instrument department, Petro Mechanics Research Division of Borg-Warner Corp., North Hollywood, Calif. He was research engineer at the central research laboratory, Borg-Warner Corp., Bellwood, Ill.

CLIFFORD W. SMITH, formerly with ACF-Brill Motors, Philadelphia, as chief aircraft liaison engineer, is now employed by Raleigh Fibreglass Corp., Doylestown, Pa. He is plant superintendent.

Changes at GMC's Detroit Diesel Engine Div.

Shoemaker

Gadebusch

Guernsey

Armstrong

F. GLEN SHOEMAKER, executive engineer of the Detroit Diesel Engine Division of GMC, Wayne, Mich., has retired after 25 years association with General Motors Diesel Engine. Shoemaker is currently an SAE Councilor.

HANS GADEBUSCH has been appointed liaison engineer with General Motors Overseas. Prior to this assignment, Gadebusch was fuels and lubricants engineer for General Motors Detroit Diesel Engine Division.

ROBERT W. GUERNSEY has been appointed special problems engineer in the turbojet engineering section of GMC's Allison Division. He was senior engineer at the Wayne plant of Detroit Diesel Engine Division.

DONALD J. ARMSTRONG is now supervisor of the engineering laboratory at the division's Wayne, Mich. plant. Before this appointment, he was on special assignment of production problems at the same plant.

SAE Members Join Hands

SAE members join hands after agreeing on a merger of the Studebaker Corp. and the Packard Motor Car Co., under the name of the Studebaker-Packard Corp. Left to right are: **JAMES J. NANCE,** president of the new company; **PAUL G. HOFFMAN,** board chairman; and **HAROLD S. VANCE,** chairman of the executive committee.

Nance was president of Packard; Hoffman was board chairman of Studebaker; and Vance, Studebaker president.

Executive offices will now be maintained at both South Bend and Detroit.

FRED C. RUNFOLA is now chief of the Plans Division, Department of the Air Force, at Mallory Air Force Depot, Memphis, Tenn. He is responsible for developing and implementing new management concepts for the directorates of maintenance engineering, supply, procurement, and production in the automotive field, reporting directly to the commanding officer of the depot. Runfola was vehicle program coordinator, Department of the Air Force, at Robins AFB, Macon, Ga.

(Transfer of complete automotive responsibilities has taken place from Warner Robins Air Materiel Area, Robins AFB, Ga., to Mallory Air Force Depot. World-wide responsibilities are now directed from Mallory, and automotive is now divorced from aircraft and from an aircraft air materiel area.)

SAE members who have been named to the advisory board of the International Aviation Trade Show are: Roy T. Hurley, president of Curtiss-Wright; **ROBERT M. DURHAM,** president, Durham Aircraft Service, Woodside, N. Y.; **THOMAS Z. FAGAN,** director, sales and service, Scintilla Magneto Division, Bendix Aviation Corp., Sidney, N. Y.; and **FRED B. LEE,** Civil Aeronautics Administrator.

The 1955 show, fourth to be held, is sponsored by Aircraft Trade Shows, Inc., New York, and is scheduled for next May 4, 5, and 6, at the 69th Regiment Armory, New York City.

CARROLL RUSSEL ALDEN, research engineer of the Ex-Cell-O Corp., Detroit, has been elevated to the grade of Fellow of The American Society of Mechanical Engineers.

LOUIS J. ROHL has been appointed to the newly-created position of chief metallurgical engineer of United States Steel Corp. He was chief metallurgical engineer, operations-steel. (In 1953 Rohl spent several months in Europe as a government consultant for the European Steel Industry.)

NEIL H. PERKINS has been released from active duty with the U. S. Air Force and is now employed in a civilian position by the USAF. He is in the propulsion section, Technical Analysis Division as aeronautical powerplant engineer, at the Technical Intelligence Center, Wright-Patterson Air Force Base, Ohio.

MORRIS C. ANDERSON is now head of the special application development department, Owens-Corning Fiberglas Corp., Newark, Ohio. He was assistant vice-president in charge of the Plastic Division, Metalcraft Mfg. Co., Phoenix, Arizona.

BURTON A. FIERSTINE is with the Saginaw Steering Gear Division of GMC as a trainee. Prior to joining GM he was doing graduate work at Michigan State College.

TIMOTHY W. MERRILL is director of product research for the Vanadium Corp. of America, Cambridge, Ohio. Merrill was chief metallurgical engineer for VCA.

JOHN NEWELL III is president and treasurer of Newell Industries, Inc., Willoughby, Ohio, designers and builders of tools and dies, jigs and fixtures, and special machines. Newell was formerly staff assistant, sales, for The Cleveland Graphite Bronze Co., Cleveland.

JAMES B. BRIGHT was director of the First Annual Material Handling Conference held last July, at the Lake Placid Club, Essex County, N. Y. Held over a two-week period, the course consisted of lectures, problems, and case studies directed by material handling specialists. Currently Bright is lecturer in industrial management at the Graduate School of Business Administration, Harvard University. For four years before that he was editor-in-chief of "Modern Materials Handling", magazine.

Litchfield Celebrates Golden Wedding Aniversary

PAUL W. LITCHFIELD, board chairman of the Goodyear Tire & Rubber Co., is shown above with Mrs. Litchfield at their golden wedding anniversary party. More than 600 industrial and society leaders joined in the celebration at the Litchfield home, "The Anchorage," Akron, Ohio.

George Round Retires from Socony-Vacuum; Becomes API Consultant

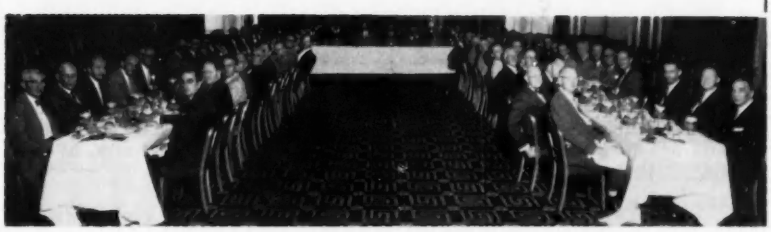
GEORGE A. ROUND, retired chief automotive engineer of Socony-Vacuum Oil Co.'s Automotive Division of the lubricating department, has become consultant to the API's Lubrication Committee, New York headquarters. He is moving his home to Sag Harbor, N. Y.

Round had been affiliated with Socony-Vacuum since 1914. During World War II, he served as consultant to the Office, Chief of Ordnance, on fuel and lubricant problems.

He has been chairman of SAE's Torque-Converter Fluids Subcommittee of SAE's Fuels and Lubricants Technical Committee, and is author of many SAE technical papers.

At left is Round as he appeared when he spoke to his Socony-Vacuum friends at the retirement party held for him last June 30.

Below is photo showing his many friends who were present.



Fruehauf Gets Honor Degree

ROY FRUEHAUF, president of Fruehauf Trailer Co., has been awarded the honorary degree of Doctor of Commercial Science at the 70th annual commencement of Tri-State College, Angola, Ind. Fruehauf was cited by the college as a "progressive industrialist, master salesman, outstanding administrator and nationally recognized authority on motor transport and highways."

Fruehauf was also honored late last June at the National Truck Trailer & Equipment Show sponsored by the Automotive Council of Los Angeles. Council President John F. Beach said Fruehauf made notable effort in the field of legislation affecting the automotive industry.

Temple University Honors Lyon

G. ALBERT LYON, SR. (right) is shown receiving the honorary degree of Doctor of Science from Dr. Robert L. Johnson (left), president of Temple University, Philadelphia. Lyon is president of Lyon, Inc., auto part dealers. He was honored as an alumnus of the University, as an industrialist, and for work with the Bimini natives, Bahama.

NORMAN R. HOLEN is with McDonnell Aircraft Corp., St. Louis, Mo., as design engineer in the company's Airplane Division. He was project engineer at Kalamazoo Mfg. Co., Kalamazoo, Mich.

SAMUEL TARAN, JR. is an engineering checker for Aero Detroit Engineering, Inc., Detroit. He was chassis designer for Chrysler at Highland Park, Mich.

C. FRANK PERVIER is now staff engineer for Caterpillar Tractor Co.'s Engine Division, Peoria, Ill. Prior to joining Caterpillar, Pervier was chief engineer for Baldwin-Lima-Hamilton Corp., Philadelphia.

GIRARD N. CONTI has joined the O'Grady Tool Co., Mount Clemens, Mich., as sales engineer. Conti was with V. L. Graf Co., Romeo, Mich., as chief engineer.

DONALD E. FLINN has been transferred from Aero Engineering Co.'s Indiana office to head the company's sales' activities in the St. Louis area. Aero Engineering, a division of The Garrett Corp., recently opened this new office in St. Louis.

DR. EUGENE WILLIHNGANZ has been appointed as engineering staff consultant of Gould-National Batteries, Inc., reporting to the vice-president in charge of engineering. Dr. Willihnganz has been in charge of research for the company.

JOHN M. SIMONETTI, formerly technical engineer for General Electric Co.'s Aircraft Gas Turbine Division, Cincinnati, is now with Processes Research, Inc. of Cincinnati.

LYLE EUGENE CALKINS is with Champion Textile Finishing Co., Chicago, as chief chemist. Calkins was formerly with Willys Motors, Inc., Toledo, as chief chemist.

F. A. SAWYER is general sales manager of manufacturers' products for the U. S. Rubber Co., New York. He was development manager for the company at Mishawaka, Ind.

CLARENCE M. NORDMAN has joined the Perfect Circle Corp., Hagerstown, Ind., as production engineer. Nordman was previously with the World Bestos Division of Firestone, New Castle, Ind., as development engineer.

HENRY A. SHERWOOD is now head of product development for Sound Scriber Corp., New Haven, Conn. Prior to joining Sound Scriber, Sherwood was vice-president in charge of engineering for Uni-Flo Engine Corp., Tarrytown, N. Y.

RAY BRUNDIGE, vice-president of Columbia Terminals Co., St. Louis, was on the Awards Committee of the National Truck Leasing System's annual Charles P. Clark Memorial Award contest which closed last June.

HOLDRIDGE WALDRON MARSH has become design engineer, research, for North American Aviation, Inc., Slauson Facility, Los Angeles. Marsh formerly was project design engineer at the Research Division of Amgears, Inc., Detroit.

GEORGE N. W. BENNETT has become director of quality control and liaison engineering for American Electric Motors Inc. of Los Angeles. Bennett was formerly plant superintendent in charge of production and engineering for Gaines-Collins Co., Los Angeles.

JOHN D. BUCHANAN has joined the Electronics Division of American Car & Foundry Industries. Prior to joining ACF Industries, Buchanan was senior mechanical design engineer for Airtronic Research, Inc., Washington, D. C.

DAVID H. BROWN has been appointed director of engineering and research of the New Process Gear Corp., Syracuse, N. Y. Brown was previously chief engineer of Chrysler Corp.'s Delaware tank plant, Newark, Del.

Brown

Crowley

DR. CLYDE A. CROWLEY has been appointed to head the Engineering Development and Research Division of Given Mfg. Co. at the main plant in Los Angeles as well as the research laboratory in Bethesda, Md. He was formerly chairman of the industrial research consultant firm of Graham, Crowley, and Associates, Inc., of Chicago and Jenkintown, Pa.

WALTER FREDERICK KELLER is serving with the U. S. Army. He is a mechanical engineer and research assistant. Keller was associate engineer, strength test, for Douglas Aircraft Co., Santa Monica, Calif.

Realignment at Clark Equipment Company . . .

King

Schultheis

Schirmer

A realignment of executive responsibilities in the Automotive Division and the Industrial Truck Division of Clark Equipment Co. has been announced by **GEORGE SPATTA**, president.

CHARLES H. KING, vice-president, will exercise overall direction of the Automotive Division, including product development, engineering, manufacturing, sales and service functions. Formerly, King was in charge of manufacturing operations. **E. M. SCHULTHEIS**, vice-president, previously in charge of Automotive Division sales, will now serve as a consultant to the president. **W. E. SCHIRMER**, vice-president, previously in charge of Industrial Truck Division sales, will now be assigned to handle special projects involving management planning, market research and other corporate matters.

E. J. WICKENDEN is with the Provincial Transport Co., Montreal, P. Q., Canada, as maintenance supervisor. He was service representative for the Automotive Division of Canadian Car & Foundry Co., Ltd., Montreal.

EVERT C. HOKANSON has joined Wallace O. Leonard, Inc. of Pasadena, Calif. He will establish a sales engineering and contract administration activity for this company. He was recently sales administrator for G. M. Giannini & Co., Inc., Pasadena, Calif.

Hokanson

King

FRANK S. KING has been appointed as technical manager for tires at Dunlop Tire and Rubber Corp. In his new capacity, King will supervise product development, technical service and quality control of tire and tube manufacture. King was with the Firestone Tire and Rubber Co. where he was assistant to the development manager, as well as head of several production departments.

M. J. SEVERINO has been promoted to district manager for Mack Trucks, Inc., with headquarters at Albany, N. Y. He was formerly in the Chicago office of Mack as manager of the Bus Division in the Middle West.

Severino

Allen

R. C. ALLEN, former New York zone manager for the Bendix Products Division of Bendix Aviation Corp., has been appointed Eastern district manager for Bendix Products.

JACK L. GOCKEL is associate research engineer in the product use laboratory of Continental Oil Co., Ponca City, Oklahoma. He was detail engineer, at GMC's Buick Motor Division, Flint, Mich.

CLYDE H. McMILLAN has become sales engineer for the F. J. Stokes Machine Co., Inc., Philadelphia. McMillan previously worked for the American-La France Foamite Corp., Elmira, N. Y., as assistant manager, motor fire apparatus sales engineer.

Obituaries

RAYMOND M. FERRIS

Raymond M. Ferris, technical editor of SAE Journal, passed away August 5, after a brief illness, in Tarrytown, N. Y. He was 30.

Ferris came to SAE in February, 1951, and for the past year or so was responsible for a major portion of the feature articles in SAE Journal. He had worked with many SAE authors in editing technical articles and in reporting SAE national meetings.

Before coming to SAE, Ferris was a field investigator for Good Housekeeping Magazine, checking technical aspects of complaints received by the publication under its guaranty seal.

In 1948, after receiving a degree of Bachelor of Science in Mechanical Engineering, from the University of Pennsylvania, Ferris went to work for Allis-Chalmers Mfg. Co. As a trainee in the company's graduate training course, he worked at the Boston circuit breaker plant and at the Milwaukee plant.

BENJAMIN K. KIRK

Benjamin K. Kirk, design and preliminary engineer for Baldwin-Lima-Hamilton Corp., died June 9. He was 72.

Kirk entered industry as draftsman and designer for The Baldwin Locomotive Works, Philadelphia. His work at Baldwin covered steam, gasoline, diesel, and all types of electric locomotives.

He attended Drexel Institute in Philadelphia, where he studied mechanic arts. A native of Pennsylvania, he was born at Dresher.

WALTER S. HOWARD

Walter S. Howard, who was former general manager of the Lake City Malleable Co., Ashtabula, Ohio, and sales representative for Rockwell Spring and Axle Co., died July 27. He had celebrated his sixty-seventh birthday several weeks before.

Howard entered industry with the Warner Gear Co. in Muncie, Ind., as a foreman. At Warner, he learned the machinist's trade and held executive positions in connection with all departments. Later he became service engineer for the Muncie Foundry & Machine Co.

During World War I, he was a major in the U. S. Quarter Masters Corps. He was in charge of inspection of all automotive units under Major D. S. Devor and Colonel Glover in the Cleveland district.

In 1918, he rejoined Muncie Foundry & Machine Co. as sales and service engineer, representing the firm and taking care of sales in the entire territory.

In 1924 he became assistant to the general manager. Two years later he joined White Motor Co. as chief inspector.

He was born at Henry County, Ind., attended high school, and later took a mechanical engineering course from the International Correspondence Schools.

JAMES NELSON JOHNSON

James Nelson Johnson, president of Johnson Motor Lines, Inc., Charlotte, N. C., died June 23. The previous day had been his forty-seventh birthday.

Johnson was vice-president of Mecklenburg Tire Co.; director of United Equipment & Service, Inc.; and a board member of Atlantic Terminals & Warehouses, Inc., all located in Charlotte. At Atlanta, Ga., he was president of Equipment Leasing Co.; president, Georgia Interstate Realty Co.; and board member of Highway Service, Inc. He was president of Mobile Realty Co., Mobile, Ala., and vice-president, Wanda Realty Co., Baltimore.

He was born at Lancaster, S. C.

Besides the SAE, Johnson held membership in the National Defense Transportation Association, the Elks Club, Carmel Country Club, and the Cat Kay Club of Cat Kay in the Bahamas. He attended Myers Park Presbyterian Church.

FRANK B. CHADWICK

Frank B. Chadwick, secretary and service parts manager of Aircooled Motors, Inc., Syracuse, N. Y., died suddenly July 11. He was 60.

Chadwick joined Aircooled Motors in 1933, in charge of engineering records, specifications, and bookkeeping. Six years later he was made service manager.

Before joining Aircooled, he was with H. H. Franklin Mfg. Co., also in Syracuse. At Franklin he was in charge of records and specifications in the engineering department.

He was born at Binghamton, N. Y., and attended public schools and business college there. Later he studied music at Syracuse University.

CHARLES S. DAVIS

Charles S. Davis, 77, chairman of the board and formerly president of Borg-Warner Corp., died July 2.

He died in Paris while on a European tour with Mrs. Davis.

Davis was with Borg-Warner Corp. since 1928. Previously he held the positions of secretary, treasurer, and president of Warner Gear Co. At one time he was also secretary, treasurer, and president of Hascock Bros. Mfg. Co.

He received the A.B. degree from Harvard in 1899.

Students Enter Industry . . .

BERT E. FORSMAN (University of Washington '54) is a tool engineer at the Boeing Airplane Co., Seattle.

JACK H. KERNS (Fenn College '54) is with Commonwealth Associates, Inc., Jackson, Mich.

FRED T. WEISMAN (Parks College '54) is now an engineer in the J-46 assembly and test section, at the Aviation Gas Turbine Division of Westinghouse Electric Corp., Kansas City, Mo.

WALTER HAROLD BERGLER (Yale '54) is now with E. I. du Pont de Nemours & Co., Niagara Falls, N. Y. Bergler is a junior engineer.

LaVERNE GENE EKLUND (California Institute of Technology '54) is an analytical engineer for Pratt & Whitney Aircraft, Division of United Aircraft Corp., East Hartford, Conn.

S. VERNON STOKER (Indiana Technical College '53) is now a senior detailer at the Saginaw Steering Gear Division of GMC, Saginaw, Mich.

PETER C. TAPPAN (University of Massachusetts '54) has joined the Research Division of United Shoe Machinery Corp., Beverly, Mass., as a mechanical engineer.

DAVID PETERSON (Purdue University '54) is now a design engineer at the Heil Co., Milwaukee.

DAVID S. MURRAY (Yale University '54) is an ensign in the operations department of the U. S. Navy.

GERALD KNIP, JR. (Purdue University '54) has joined the Allis-Chalmers Mfg. Co., Milwaukee.

SCOTT R. FOSTER (U. S. Naval Academy '54) is now an ensign.

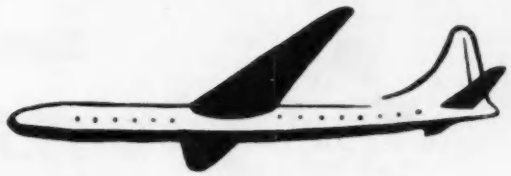
RUNE ENGBLOM (Case Institute of Technology '54) has become a design engineer at the National Electric Welding Machines Co., Bay City, Mich.

WILLIAM T. COLLINS, JR. (Lehigh University '54) is with the Pontiac Motor Division, GMC, Pontiac, Mich., as a test engineer.

GERMAINE C. LOCKWOOD (Chrysler Institute of Engineering '54) is an engineer in the truck chassis design department of Chrysler.

BARNEY A. HEKKALA (Northrop Aeronautical Institute '54) has joined the engineering staff at H. C. Little Burner Co., San Rafael, Calif.

1954 SAE National Aeronautic Meeting



Aircraft Production Forum **Engineering Display**

October 5-9 **Hotel Statler** **Los Angeles, Calif.**

TECHNICAL SESSIONS will bring to light answers to today's problems. For instance . . .

★ **STRUCTURES** . . . putting muscle into thin wings
★ **ENGINES** . . . jets, new fuels, new designs
★ **MATERIALS** . . . tailoring metals and plastics to tougher needs
★ **PACKAGING** . . . isolation from shock and vibration

PRODUCTION FORUM panels will be keyed to the theme "Planned Flexibility for Defense." . . . 10 informal panel discussions at which specialists will dish up answers on daily problems related to . . .

Machining
Change Control
Education in Industry
Quality Control
Electronics
Economics of Tooling
Forming
Effective In-Plant Communication
Manufacturing Cost Control
Tabulating-in-Industry

SPECIAL FEATURES

★ **Talk on Atomic Energy by Carl Hinshaw,** Member, House of Representatives, and Ranking Majority Member, Joint Committee on Atomic Energy, Congress of the United States

★ **Progress Report on Canadian Aviation by Clarence Decatur Howe,** Minister of Trade and Commerce and Minister of Defence Production, Canada, and Daniel Guggenheim Medalist

★ **Dinner-Dance on Saturday, October 9**

Boston Beckons You to the

1954 SAE National Transportation Meeting

October 18-20, 1954

The Sheraton Plaza Boston, Massachusetts

Hear about new transportation developments, such as . . .

- Two-Level Intercity Bus
- Nickel-Cadmium Batteries
- Electronic Vehicle-Weighing Scales
- Latest Truck Development Center

Hear new evidence on current controversies, such as . . .

- Outdoor storage versus shelters for vehicles
- Ways to better weight distribution

SPECIAL EVENTS

1. Tour of U. S. Coast Guard Base
2. Old meets the new in display of antique cars as well as current experimental models.
3. Truck and bus engineering display
4. Dinner address by ROBERT F. BLACK, president, The White Motor Co.

Sponsor Chapline Names Hegner To Chairman N. Y. Production Forum

A. B. (AL) HEGNER (at right in photo), production manager, Fairchild Engine Division, Farmingdale, New York, has been appointed general chairman of the 1955 SAE Production Forum, scheduled for next April. The appointment was announced by George F. Chapline (at left in photo), Fairchild vice-president and general manager of the Engine Division, and sponsor of the Forum.

Hegner is a graduate of Pratt Institute, Class of 1938, and holds an IME and ME degree. He has 16 years service with Fairchild Engine Division, having joined Fairchild upon graduation from Pratt. He was in charge of experimental production control, Manager of experimental manufacturing for four years, and was division production control manager until last September, when he was elevated to production manager.

Hegner has helped build the Aeronautic Production Forum since its inception two years ago. He has served on the executive committee and was leader of the panel on production control last April at the '54 Forum.

Sponsor Chapline, Chairman Hegner, and members of their Executive Committee will set to work planning the '55 program, this month.

SAE National Meetings . . .

September 13-16, 1954
National Tractor Meeting & Production Forum
Hotel Schroeder,
Milwaukee, Wis.

October 5-9, 1954
National Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

October 18-20, 1954
National Transportation Meeting and Truck and Bus Engineering Display
The Sheraton-Plaza
Boston, Mass.

October 26-28, 1954
National Diesel Engine Meeting
Hotel Statler,
Cleveland, Ohio

November 4-5, 1954
National Fuels and Lubricants Meeting
The Mayo,
Tulsa, Okla.

January 10-14, 1955
Golden Anniversary Annual Meeting and Engineering Display
The Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Mich.

March 1-3, 1955
Golden Anniversary Passenger Car, Body and Materials Meeting
The Sheraton-Cadillac Hotel,
Detroit, Michigan

March 14-16, 1955
Golden Anniversary Production Meeting and Forum
Netherland Plaza,
Cincinnati, Ohio

April 18-21, 1955
Golden Anniversary Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Statler and McAlpin Hotel, New York, N. Y.

June 12-17, 1955
Golden Anniversary Summer Meeting
Chalfonte-Haddon Hall,
Atlantic City, N. J.

August 15-17, 1955
Golden Anniversary West Coast Meeting
Hotel Multnomah
Portland, Oregon

September 12-15, 1955
Golden Anniversary Tractor Meeting and Production Forum
Hotel Schroeder
Milwaukee, Wisconsin

Tentative Filter Test Gives Good Agreement

THE Oil Filter Test Method Subcommittee is making steady progress on its long-term task of devising, checking, and refining a filter test method and test contaminants for standardization.

Sherod L. Earle of the Subcommittee's analysis group noted at the Subcommittee's last meeting that:

1. The general test method the Subcommittee has been following for recent cooperative testing gives reasonably good correlation of results between four reporting laboratories. (Reports from additional laboratories are expected before the Subcommittee meets again Oct. 27 at the SAE National Diesel Engine Meeting in Cleveland.)

2. If the test contaminant is to be homogenized in a gear pump, it's important that agitation time be limited. Prolonged agitation grinds the contaminant particles to a fineness that makes them harder to filter. Agitation by centrifugal pump does not present this difficulty and is the preferred method.

3. Results are comparable whether the contaminant is added directly to the oil sump by continuous dropwise metering or by blending into a slurry for dropwise addition via a quadrant.

Naval Lab Runs 100's of Test Hours

Earle, who is with the U. S. Naval Engineering Experiment Station, is preparing an analysis report of the test data in cooperation with C. J. Lauer of AC Spark Plug Division. The Naval Engineering Experiment Station—along with the laboratories with which the other Subcommittee members are associated and which were listed on page 93 of the March SAE Journal—has contributed hundreds of hours of test running.

Committee Membership

Besides Earle and Lauer, the Subcommittee membership includes: W. A. Hunter of Chrysler, chairman; R. J. Pocock of Ford, secretary; R. Beckett of Walker Mfg.; F. B. Hunt of the Detroit Arsenal; W. S. James of Fram; E. D. Kane of Cuno Engineering; and H. R. Otto of Purolator.

The Subcommittee reports to the SAE Engine Committee.

Board Approves Rule On Chairmen's Tenure

TO Section 4(a) of its Rules and Regulations the SAE Technical Board has added:

> "Reasonably frequent rotation of committee chairmen, where practical and desirable, is encouraged and renominations of chairmen who have served five or more consecutive years shall be reviewed by the Executive Committee which will report its recommendation to the Board before action is taken on such renominations."

This revision is to become effective in January 1956. At the same time addition of the words "and chairmen" to the first sentence of the section will become effective, making it read:

> "The Board will organize such technical committees as are necessary to carry on its projects and will approve the initial membership and chairman of such committees."

The Technical Board made these changes as a result of its Executive Committee's study of the tenure of committee chairmen.

New Manual Covers Blast-Cleaning Process

COMPLETE and up-to-date data on blast cleaning are covered in a new manual recently approved by the SAE Technical Board. It is to be a companion to the SAE Manual on Shotpeening, published several years ago, and to a bibliographical supplement to the Shotpeening Manual entitled, "What's Been Written about Shotpeening," to be made available shortly.

The new manual was compiled and edited by the Blast-Cleaning Subcommittee of Division XX of the Iron and Steel Technical Committee. G. F. Bush of Ford is chairman of the subcommittee.

The men responsible for the manual have extensive and varied experience with blast cleaning. Thus, they have been able to produce a handbook loaded with practical information for engineers, management, and shop personnel needing specific advice concerning the blast-cleaning process.

What the Manual Contains

Specifically, the manual includes data on:

- Blasting machines, such as air blast units, airless blast units, and wet blasting machines.
- Blasting abrasives, both vegetable and metallic.
- Recommended cleaning practices, including a chart to help in the selection of the proper abrasive size.
- Production procedures.
- Inspection.
- Shot and grit specifications.
- Life testing machines of four types.
- Shot acceptance testing method.
- Measuring shot-blasting machine efficiency.

The SAE Manual on Blast Cleaning contains 36 illustrations and 3 tables. It is available as SP-124 from SAE Special Publications Department for $2 to members, $4 to nonmembers.

Change Recommended In Clearance Lamp Cp

AS a further move to improve rear lighting on large vehicles, the Lamp and Bulb Subcommittee has recommended this change in the SAE Standard on Lighting Equipment for Motor Vehicles to its parent Lighting Committee:

> That the current minimum candlepower requirements for tail lamps apply also to clearance, side-marker, and identification lamps. (The current tail lamp minimums were adopted in January 1954 and appear on page 842 of the 1954 SAE Handbook.)

Present minimums at all test points are 0.25 cp for red and 0.75 cp for amber clearance, side-marker, and identification lamps. The proposed revisions would increase the minimums at many points. For example, at the HV point (intersection on the test screen of horizontal and vertical planes through the lamp axis), the new minimum would be 1.50 cp. At 5 deg up and down and left and right from the lamp axis, the new minimums would be 1.00 cp.

1954 SAE National Diesel Engine Meeting

October 26-28
Hotel Statler
Cleveland, Ohio

Technical Sessions of this meeting will feature reports on:

I. Two-stroke-cycle diesels

- Method of scavenging analysis.
- Supercharging investigations, including use of turbosupercharger.

II. Cold starting of diesels (both 2- and 4-stroke cycle)

- Starting fluids.
- Low-temperature testing at Fort Belvoir.
- Factors affecting starting ability of diesels.

Dinner will feature talk by

Rear-Admiral W. D. Leggett, Jr., on Future Possibilities of Diesels

Plant Tours will feature trips to

- Euclid Road Machinery Co., GMC
- Cleveland Diesel-Engine Division, GMC
- New York Central Railroad, Collinwood Shops

Special feature will be visit to

- Thompson Products Auto Album and Aviation Museum

1954 SAE National Fuels and Lubricants Meeting

The Mayo
Tulsa, Oklahoma

Thursday and Friday
November 4-5, 1954

10 papers on . . .

fuel-lubricant-engine interrelationships for gasoline, diesel, and LPG engines

plus a dinner featuring . . .

Major-Gen. John F. Uncles
Chief of Research and Development,
U. S. Army

Aero Materials Specs Reviewed by Industry

DRAFTS of twenty SAE Aeronautical Materials Specifications are currently being circulated to industry for comment and criticism by the SAE Aeronautical Materials Specifications Division. Twenty-nine specifications have been approved recently by the SAE Technical Board.

Copies of all of these specifications are available for review from the SAE Aeronautical Department, 29 West 39 Street, New York 18, N. Y.

The specifications under review are:

- AMS —— Steel Strip, Silver Clad;
- AMS —— Aluminum Alloy Sheet and Plate, Aluminum Alloy Clad 6.8Zn-2.75Mg-2.0Cu-0.29Cr (Alc. 78S-T6);
- AMS —— Aluminum Alloy Sheet and Plate, Aluminum Alloy Clad 6.8Zn-2.75Mg-2.0Cu-0.29Cr (Alc. 78S-O);
- AMS —— Rings, Packing, Synthetic Rubber, Fuel and Low Temperature Resistant (70–80);
- AMS —— Bolts and Screws, Steel, Corrosion and Heat Resistant, Roll Threaded;
- AMS —— Potting Compound—Foamed Epoxy Type, Amine Hardened;
- AMS —— Steel Wire, Corrosion Resistant, 17Cr-7Ni-1Al Precipitation Hardening—Spring Temper;
- AMS —— Spot Welding of Commercially Pure Titanium;
- AMS —— Brazing Alloy—Nickel Base-4Si-7Cr-3Fe-3B;
- AMS —— Brazing Alloy—Nickel Base-4Si-2.6B;
- AMS 2410B—Silver Plating—Nickel Strike—High Bake;
- AMS 2412B—Silver Plating—Copper Strike—Low Bake;
- AMS 2645C and AMS 2646;
- AMS 4925A—Titanium Alloy, 4Al-4Mn, Annealed-130,000 psi Yield;
- AMS 5370—Steel Castings, Precision Investment, Corrosion and Heat Resistant, 19Cr-10Ni (Low Carbon);
- AMS 5371—Steel Castings, Sand, Corrosion and Heat Resistant 19Cr-10Ni (Low Carbon);
- AMS 5536A—Alloy Sheet, Corrosion and Heat Resistant, Nickel Base-22Cr-1.5Co-9Mo-0.6W-18.5Fe;
- AMS 6470E—Steel, Nitriding, 1.6Cr-.035Mo-1.15Al (0.38–0.43C);
- AMS 6475B—Steel, Nitriding, 3.5-Ni-1.2Cr-0.25Mo-1.25Al (0.21-0.26C);
- AMS 7310C—Piston Rings, Cast Iron.

The approved specifications are:

- AMS 2241C—Tolerances, Corrosion and Heat Resistant Steel Bars, and Titanium and Titanium Alloy Bars;
- AMS 2430B—Shot Peening;
- AMS 3130B—Paint Vehicle;
- AMS 3201E—Synthetic Rubber, Dry Heat Resistant (35–45);
- AMS 3207D—Synthetic Rubber, Weather Resistant, Chloroprene Type (25–35);
- AMS 3208D—Synthetic Rubber, Weather Resistant, Chloroprene Type (45–55);
- AMS 3213F—Synthetic Rubber, Aromatic Fuel Resistant (75–85);
- AMS 3215F—Synthetic Rubber, Aromatic Fuel Resistant (65–75);
- AMS 3240B—Synthetic Rubber, Weather Resistant, Chloroprene Type (35–45);
- AMS 3241B—Synthetic Rubber, Weather Resistant, Chloroprene Type (55–65);
- AMS 3270C—Synthetic Rubber Sheet, Cotton Fabric Reinforced;
- AMS 3626B—Plastic Moldings and Extrusions;
- AMS 3851A—Fire Resistant Properties for Aircraft Materials;
- AMS 3852A—Flame Resistant Properties for Aircraft Materials;
- AMS 3855A—Flame Resistant Treatment of Interior Fabrics;
- AMS 4047A—Aluminum Alloy Sheet and Plate, Aluminum Alloy Clad, Roll Tapered;
- AMS 4137A—Aluminum Alloy Forgings;
- AMS 4286—Aluminum Alloy Castings, Permanent Mold;
- AMS 4575B—Nickel-Copper Alloy Tubing, Brazed, Corrosion Resistant;
- AMS 4766—Brazing Alloy, Silver;
- AMS 4768—Brazing Alloy, Silver;
- AMS 4901A—Titanium Sheet and Strip, Annealed;
- AMS 5047—Steel Sheet and Strip;
- AMS 5697—Steel Wire, Corrosion Resistant;
- AMS 5768B—Alloy, Corrosion and Heat Resistant, Iron Base;
- AMS 6460—Steel Wire;
- AMS 7270B—Rings, Sealing, Synthetic Rubber, Fuel Resistant (65–75);
- AMS 7274C—Rings, Sealing, Synthetic Rubber, Oil Resistant (65–75);
- AMS 7470A—Bolts and Screws, Steel, Corrosion Resistant.

Correction . . . SAE Handbook

SAE 311 aluminum alloy has very good corrosion resistance, the SAE Standard on Aluminum Casting Alloys should say. The statement that "Its corrosion resistance under extreme conditions is approximately the same as SAE 306 but not as good as SAE 305" is in error. The incorrect statement appears on page 237 of the 1954 SAE Handbook.

Technishorts . . .

SHELL MOLDING—T. W. Curry of Lynchburg Foundry Co. has been named Chairman of Division XXVI—Shell Molding of the SAE Iron and Steel Technical Committee. He is reactivating the Division.

SMALL ENGINE STANDARDIZATION—The SAE Engine Committee has formed a Small Aircooled Gasoline Engine Subcommittee. Aim of the subcommittee is to develop standards for ½ to 3-hp engines used in lawn mowers and similar engines.

First subjects under consideration for standardization are (1) performance testing, (2) safety requirements for rotary mower engines, and (3) carburetor, muffler, and air cleaner attaching dimensions.

SAE Student News

Northrop Wants to Win!

Northrop Aeronautical Branch members are out to win again the Mac Short Memorial Award, sponsored by the Southern California Section. Northrop Branch members received the plaque for 1951 and '52, the first two years it was presented. In 1953, and '54, however, Dave McKinley and Stanley Adkins, both of California State Polytechnic, were recipients.

The award is presented annually to a student member at one of the Southern California technical schools, who "has contributed the most to engineering during the year." The award is a memorial to the late Mac Short, who was a vice-president of Lockheed Aircraft Corp. and a past SAE president.

On July 23, the Branch listened to Mel Hall, student activities advisor for the Southern California Section, who gave a brief history of the award.

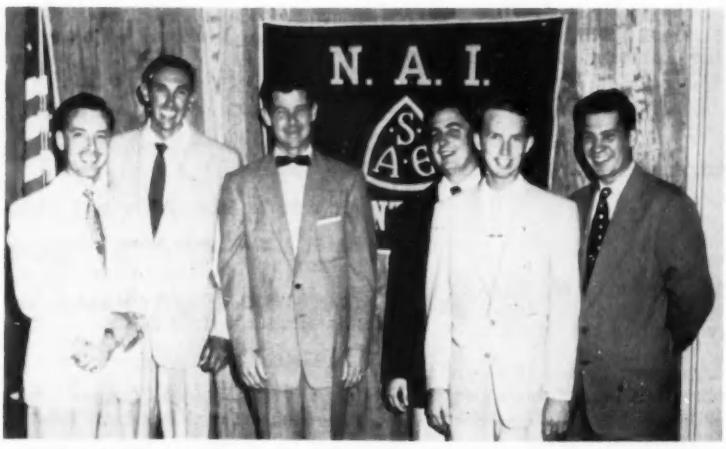
William Martin, who was the first winner of the plaque in 1951, and Arthur Eck who received it in '52, reviewed their personal experiences and the satisfaction they received in preparing for and finally winning the plaque for the Northrop Branch.

The three speakers, all Northrop Aeronautical Institute and SAE Branch Alumni, spent the greater part of the meeting answering questions and discussing points of interest with the students.

At the same meeting, Paul Tomlinson, representative of the Pacific Telephone and Telegraph Co., presented a lecture and demonstration, "The Application of Micro Waves to Communication and Television Networks." The highlight of his presentation was an actual demonstration of a miniature micro wave radio relay system.

Tomlinson's guest appearance was so interesting that the students have scheduled him for a future lecture on transistors.

They Ran the Show



Above are SAE student members at Northrop Aeronautical who ran the July 23 Branch meeting, with Guest Speaker Paul W. Tomlinson (third from left). Tomlinson is representative of the Pacific Telephone and Telegraph Co. Students are, left to right: Clinton L. Darling, program chairman; Robert E. Schenk, chairman; (Tomlinson); William F. Dawson, vice-chairman; Rodney Larsen, treasurer; and Clyde S. Burkhardt, secretary.

Section Meetings Schedule

Atlanta—Sept. 13

Ship-A-Hoy Restaurant. Topic and Speaker unknown.

Buffalo—Sept. 21

Plant Tour. Dinner 6:30 p.m. American Machine & Foundry, Buffalo, N. Y.

Canadian—Sept. 13

Hamilton Golf & Country Club, Ancaster, Ont., Canada. Dinner 7:00 p.m. "Forging in Closed Dies"—a film presented by Drop Forgings Association.

Central Illinois—Sept. 27

American Legion Hall, Peoria, Ill. Dinner 6:30 p.m., meeting 7:45 p.m. Pan American Road Races—Joseph R. Gillette, assistant manager, Lincoln Product Planning Dept., Lincoln-Mercury Div., Ford Motor Co., Detroit, Mich.

Chicago—Sept. 10 and 20. Oct. 12

Sept. 10—Olympia Fields Country Club. Dinner 6:00 p.m. Eleventh Annual Playday and Golf Outing. Golf, dinner, entertainment, music, prizes.

South Bend Div.—Sept. 20

LaSalle Hotel, Bronzewood Room, Michigan & LaSalle Sts., South Bend, Ind. Dinner 6:30 p.m., meeting 8:00 p.m. The 1953 Mexican Pan-American Road Race—Joseph R. Gillette, assistant manager, Lincoln Product Planning Dept., Lincoln-Mercury Div., Ford Motor Co., Dearborn, Mich. Moving Pictures of the race, in color.

Oct. 12—Hotel Knickerbocker, Grand Ballroom, 163 E. Walton, Chicago. Dinner 6:45 p.m., meeting 8:00 p.m. Social half-hour before dinner, 6:15 to 6:45 p.m.

Cleveland—Sept. 13

Cleveland Foundry, Ford Motor Co. Dinner 6:30 p.m., meeting 7:30 p.m. Effect of Engineering of Today on Foundry of Today—E. C. Jeter, plant manager and selected representatives from his immediate staff, Cleveland Foundry, Ford Motor Co., Brookpark Rd., Cleveland, Ohio. Plant tour preceding dinner.

Detroit—Oct. 4

Rackham Educational Memorial Bldg., large auditorium. Dinner Meeting. The Firebird—representatives of

General Motors Corp. The Firebird and a bus will be exhibited. There will be a question and answer period.

Metropolitan—Sept. 16 and Oct. 7

Sept. 16—The Brass Rail, 43rd St. and 5th Ave., New York. Cocktail Hour 5:30 p.m. Dinner 6:30 p.m., meeting 7:45 p.m. Atomic Powered Vehicles—Ken Kasschau, manager, Atomic Energy Dept., American Locomotive Co. Dinner price: $3.75 to members and $4.75 to nonmembers.

Oct. 7—The Brass Rail, 43rd St. and 5th Ave., New York. Cocktail Hour 5:30 p.m. Dinner 6:30 p.m., meeting 7:45 p.m. Brakes, Heavy-Duty, Commercial—O. E. Johnson, vice-president, Brake & Electric Sales Corp. Dinner price: $3.75 to members and $4.75 to nonmembers.

Mid-Continent—Sept. 17

Hotel Tulsa, Tulsa, Okla. Dinner 6:30 p.m., meeting 7:30 p.m. Boeing 707 Transport—Maynard L. Pennell, chief project engineer, Boeing Airplane Co., Seattle, Wash.

Mid-Michigan—Oct. 4

Oldsmobile Engineering Auditorium, Lansing, Mich. Dinner 7:00 p.m., meeting 8:00 p.m. Historical Highlights of Automotive Development—A. T. Colwell, vice-president, Thompson Products, Inc., Cleveland, Ohio. Display of antique automobiles representative of basic designs and periods. Social hour and inspection period preceding the dinner.

Mohawk-Hudson—Oct. 12

Circle Inn, Latham, N. Y. Dinner 6:45 p.m., meeting 8:00 p.m. Golden Anniversary Meeting. We have planned to make this meeting an organization meeting to introduce the new officers, explain their function; also to give a brief history of National SAE and Mohawk-Hudson Group.

Oregon—Sept. 16 and Oct. 9

Sept. 16—Congress Hotel, Portland, Ore. Dinner 7:00 p.m., meeting 8:00 p.m. Cummins P. T. Fuel System—C. J. White, manager, N. W. Region, Cummins Engine Co., Inc., Seattle, Wash.

Oct. 9—Columbia-Edgewater. Dinner 7:30 p.m. Dinner and Dance. Visiting members welcome.

St. Louis—Sept. 14 and 22

Sept. 14—We are arranging a plant tour.

Sept. 22—Anheuser-Busch, Inc., St. Louis, Mo. Meeting 7:30 p.m. Plant Inspection Trip. Conducted tour of plant, with emphasis on types of machinery.

So. California—Oct. 11

Rodger Young Auditorium. Dinner 6:30 p.m., meeting 8:00 p.m. The Gas Turbine Applied to Automobiles—John Coleman, staff member, General Motors Research, Detroit, Mich.

Spokane-Intermountain—Oct. 7

Desert Caravan Inn. Dinner 6:00 p.m., meeting 7:00 p.m. Trucks Are Made By Law—R. C. Norrie, chief engineer, Kenworth Motor Truck, Seattle, Wash. Cummins P. T. Fuel Pump System—C. J. Wilhite, northwest regional manager, Cummins Engine Co.

Texas—Sept. 10 and Oct. 8

Sept. 10—Italian Village. Dinner 7:30 p.m., meeting 8:15 p.m. Motor Vehicle Air Conditioning.

Oct. 8—Dinner 7:30 p.m., meeting 8:15 p.m. Transportation and Maintenance.

Williamsport—Sept. 13

Moose Club Ballroom. Dinner 6:45 p.m., meeting 7:45 p.m. Film: "Boxcars to Pilotless Bombers," courtesy of Glenn L. Martin Co.

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from the Sections

Baltimore

May 13

FUEL ADDITIVES CAN CONTROL PREIGNITION and spark-plug fouling, according to D. P. Brenz of Shell Oil Co.

Brenz described results of **controlled road tests** using operating cycles of two minutes idle and five minutes running at 30 mph. Full-throttle accelerations were made **every 120 hr** to note preignition.

"With no TCP additive in gasoline," he said, "preignition was encountered in 75% of accelerations . . . this was reduced to only 35% using the TCP additive."

Showing slides while he talked, Brenz pointed out results of spark-plug fouling road tests in eight **new late-model cars** of two makes. The cars were operated under **metropolitan driving conditions**, including frequent stops, and top speed limited to 25 mph. Observation of engine roughness on acceleration was used as a measure of plug misfiring. From **70 to 150% improvement** in plug life was obtained with TCP additive, according to Brenz.

Northern California

Field Editor
R. E. Van Sickle
May 26

TESTING AIRCRAFT DESIGNED TO CRASH during every flight was described at the Section's Aeronautics Meeting. **The Nike missile** and other recent advances in high-speed aircraft was talked about by Dr. A. L. Klein of Douglas Aircraft Co.

Klein described research on high-speed planes, pointing out design features used to achieve special **performance characteristics.** He explained the types and purposes of different missiles, particularly surface to air missiles. Various **propellant systems** were also covered.

Sumner P. Youngblutt was technical chairman for the evening.

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Vice-chairman: **Albert S. Polk, Jr.,** senior designer, Glenn L. Martin Co.; vice-chairman Aeronautics: **Edward J. Jankovic,** Baltimore District Manager, Aeronautical Engineering, Inc.; vice-chairman Transportation and Maintenance: **Charles F. Schwarz,** charge of laboratory engineering section, Automotive Division, Department of the Army; treasurer: **W. Carroll McKenna, Jr.,** service manager, Warner Fruehauf Trailer Co., Inc.; secretary: **Maurice E. Ensor,** assistant superintendent, Automotive Maintenance and Equipment, Baltimore Transfer Co.; past chairman: **Robert M. Foster,** Department of the Navy, U. S. Naval Engineering Experiment Station.

British Columbia

Chairman: **James B. Mortimer,** automotive service engineer.

Vice-chairman: **Lyman B. McPherson,** sales and service manager, Truck Parts and Equipment, Ltd.; vice-chairman Fuels and Lubricants: **Dermot A. O'Cadlaigh,** fuel and lubricant engineer, Standard Oil Co. of B. C., Ltd.; vice-chairman Transportation and Maintenance: **Ed A. Collins,** president, general manager, Collins Mfg. Co., Ltd.; treasurer: **Clarence H. Willis,** technical supervisor, Home Oil Distributors, Ltd.; secretary: **Burdette Trout,** sales, Truck Parts and Equipment, Ltd.; past chairman: **Alan B. Reid,** truck sales manager, Wolfe Chevrolet-Oldsmobile Ltd.

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Vice-chairman: **John A. Mattison,** chief engineer, Aircraft Division, Twin Coach Co.; vice-chairman Rochester: **Howard H. Dietrich,** engineer, Rochester Products Division, General Motors Corp.; secretary-treasurer: **Albert H. Gille,** sales engineer, R. C. Neal Co.; past chairman: **Elliot W. Chapman,** industrial salesman, Esso Standard Oil Co.

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Chairman: **Randall Roman,** supervisor, General Tractor Design, Caterpillar Tractor Co.

Vice-chairman: **Robert V. Larson,** manager, Research Design and Procurement, Caterpillar Tractor Co.; vice-chairman Springfield: **T. Joseph Flamm,** experiment engineer, Allis-Chalmers Mfg. Co.; treasurer: **Loren C. Bailery,** layout draftsman, Caterpillar Tractor Co.; secretary: **Russell W. Rand,** supervisor engineering, Power Transport Laboratory, Caterpillar Tractor Co.; past chairman; **Robert E. Kennemer,** staff engineer, Research Department, Caterpillar Tractor Co.

Chicago

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Vice-chairman: **Jack A. Nelson,** lubricants engineer, Standard Oil Co. (Ind.); vice-chairman Aircraft: **Wilson A. Gebhardt,** manager, Fuel Feed engineering, Bendix Products Division, Bendix Aviation Corp.; vice-chairman Engineering Materials and Production: **Maurice J. Day,** assistant director, Program Development, Illinois Institute of Technology, Armour Research Foundation; vice-chairman Fuels and Lubricants: **Hugh L. Hemmingway,** general manager, Sales Service Department, Pure Oil Co.; vice-chairman Parts and Accessories: **William R. Mogg,** district sales representative, Cleveland Graphite Bronze Co.; vice-chairman Passenger Car: **D. J. Schrum,** body experiment engineer, Studebaker Corp.; vice-chairman Tractor, Industrial Power and Diesel Engine: **Arthur F. Ochtman,** manager, engineering, Engine Division, Buda Co., Division Allis-Chalmers Manufacturing Co.; vice-chairman Transportation and Maintenance: **Edward F. Donham,** plant supervisor, motor equipment, Illinois Bell Telephone Co.; vice-chairman Truck and Bus: **Edward D. Hendrickson,** secretary, sales manager, Hendrickson Motor Truck Co.; treasurer: **Richard L. Smirl,** assistant chief engineer, Borg & Beck Division, Borg-Warner Corp.; secretary: **W. Robert Dalenberg,** divisional chief engineer, Farm Tractor Division, International Harvester Co.; past chairman: **Merrill R. Bennett,** assistant manager, engineering, International Harvester Co.

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1954-1955

Cleveland

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Dayton

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Vice-chairman: **K. M. Watson,** superintendent, maintenance, Oahu Transport Co., Ltd.; vice-chairman Aeronautics: **Roger W. Hume,** Field Service representative, Pratt and Whitney Aircraft Division, United Aircraft Corp.; vice-chairman Hawaii: **G. D. Gedge,** resident manager, Union Oil Co. of California; treasurer: **Richard G. Deemer,** chief, Quarterman Transport, Department of the Navy; secretary: **Ivan B. Palmer,** chief mechanic, United Airlines, Inc.; past chairman: **Fred Hedemann,** vice-president, operations, Oahu Transport Co., Ltd.

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1954-1955 Section Officers

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Vice-chairman: **Ewing W. Mueseler,** instructor, Williamsport Technical Institute; treasurer: **Allen Weiss,** supervising agent, United States Department of Commerce, Civil Aeronautics Administration; secretary: **Blair S. Kratzer,** owner, EIMCO; past chairman: **Fredric G. Rohm,** chief experiment engineer, Lycoming Division, Avco Manufacturing Corp.

Fire Apparatus Engines Call for Special Care

Based on paper by

ROBERT ELY
San Diego Fire Department

SOME fire departments start engines at least once a day for testing and to insure starting if and when there is a fire. This produces a heavy sludge even if an engine is run from 10 to 15 min each time. If run long enough to bring crankcase oil temperatures up to 143F so that engines will stop "sweating," it may take as long as an hour, running at 750 rpm.

The San Diego Fire Department decided against starting an engine except to answer an alarm or for training activities. It realized that even if an engine is started every hour of the 24, it still may not start when needed. This policy diminished sludge content sharply.

Rather than wear out units by daily test, this department prefers to have a schedule of preventive maintenance and replace units before failure occurs. Furthermore, since apparatus runs with very low oil temperatures most of the time, but with high temperatures when pumping, an oil of high viscosity index has been found desirable. (Paper "Make It Easy for the Engine" was presented at SAE San Diego Section, April 14, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Bench Tests Aren't Foolproof

Based on paper by

F. S. WOOD
Standard Oil Co. (Indiana)

THE answer to the problem of sticking hydraulic valve lifters, which has become more severe with higher output engines, is not to add more and more additive to the lubricant. Nor is it to be found in developing a lubricant capable of passing a test in a diesel engine. The answer lies in selecting additives that specifically prevent sticking due to varnish and rust.

Wear on cams and cam followers calls for similar treatment. A close balance of additive combinations is needed to control wear and scuffing and to minimize the pitting of cam followers.

The additives we arrived at in developing an oil that would pass engine tests would have been overlooked in the laboratory tests designed for

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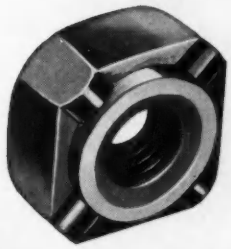

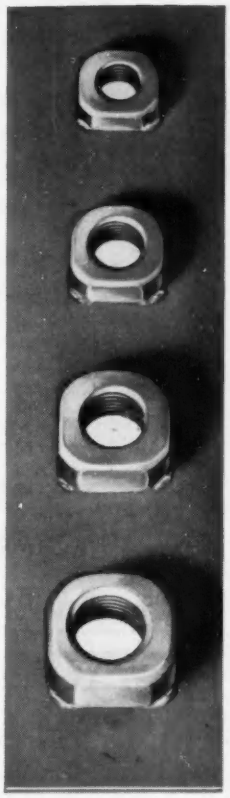

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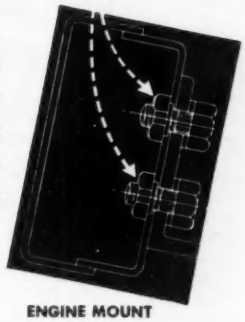

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screening. Tests should be carried on with the engine in which the problem exists rather than in an arbitrary bench test. (Paper "New Oil Designs for New Engine Designs" was presented at SAE Summer Meeting, Atlantic City, June 9, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Thank Synthetics For Today's Tires

Based on paper by

M. F. TORRENCE

E. I. duPont de Nemours & Co.

SYNTHETIC rubbers and fibers have cut tire cost, improved quality and saved the public hundreds of millions of dollars. GR-S is the large volume synthetic in passenger car tires. In truck tires its use is limited by its high heat build-up and poor cut growth resistance. Neoprene is used for protection of sidewalls against ozone cracking and sun checking. Recent tests indicate that a blend of natural rubber, GR-S, and Neoprene used in a tread might overcome the serious problem of truck tire tread cracking.

Most inner tubes are now made of butyl rubber which has airholding properties much superior to natural rubber. Neoprene also holds air better than other rubbers and may find application in liners for tubeless tires because of excellent chafing resistance. Synthetics have practically displaced cotton for tire cord fabric and the result is thinner, cooler running carcasses. (Paper "The Use of Synthetic Rubber in Pneumatic Tires" was presented at SAE Philadelphia Section, April 14, 1954. It is availible in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Two Out of Three Cars Autoignition Limited

Based on paper by

P. A. BENNETT

and

J. R. LANDIS

General Motors Corp.

WHAT is the relative importance of knock and autoignition in determining the octane requirements of passenger cars?

To throw light on this question a

test was made using a group of 33 customer-owned cars of a single make —a 1953 model OHV V-8. The cars were owner-driven for a minimum of 3000 miles without restriction as to fuel, lubricant, or style of driving before ratings were made. Octane number requirements for freedom from autoignition and objectionable knock were determined when driving a test course which included hills as well as level roads.

The results have shown that two out of three cars of this one make are autoignition limited. Furthermore, all of the cars with octane number requirements high enough to cause customer complaint on the average premium grade gasoline were autoignition limited. (Paper "Relative Importance of Knock and Autoignition in Determining Octane Requirements of Passenger Cars" was presented at SAE Cleveland Section, Jan. 18, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Road Noise Level Shows Steady Rise

Based on report by

DAVID APPS

Noise and Vibration Laboratory
General Motors Corp.

ROAD noise has become one of the major noise problems. The rise is not due to the suppression of other noises; the road noise level itself has risen. This has been proved by comparing a 1935 model car with a modern one on a test course. When going from a smooth tarvia surface to a heavily pebbled one, the sound from the old car measured a 0.2 db change, while the modern car recorded a sound level change of 6.1 db. The explanation lies in the structural differences of the cars.

Road noise can be controlled by isolating the actuating forces from the body rather than by changing the natural frequencies of body panels and parts. But with unit-frame construction noise can be suppressed to a large degree by isolating the suspension system from the body as well as by application of damping materials to the body panels.

Torque tube drive permits better control of noise than the Hotchkiss drive, but since the latter is more popular it offers a greater challenge. One way to dampen noise with the Hotchkiss drive is to mount the springs in

Round Table Participants

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General Motors Technical Center
General Motors Corp.
David Apps, Secretary
Noise and Vibration Laboratory
General Motors Corp.
P. E. Chuba
Packard Motor Car Co.
Bain Griffith
Ford Motor Co.
F. R. Kishline
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such a way that the body sills are loaded in bending but not in tension. Use of tension-type rear shackles also helps.

Axle noise can be tackled in the manufacture. Ring gears made by the non-generated process are required to mate perfectly with pinions manufactured as generated gears. The noise is caused by the top edges of the gear teeth contacting pinion profiles. This interference can be relieved by the proper procedure of undercutting the pinion profile, followed by lapping. Proper undercutting will follow only if the base circle of the profile is reasonably close to the root of the pinion teeth and across the entire face of the teeth. This is not always the case.

Both axle and gear noises can be helped by isolating the exciting forces and detuning resonant systems. In one instance, axle gear noise was traced to a resonant response of a torsional system composed of a handbrake drum as a mass, and a propeller shaft as a spring. Here a solution was reached by using softer Silent-Block bushings at the rear spring front eyes.

Tires contribute many kinds of noises. Tire makers have done much toward their elimination and vehicle manufacturers can also contribute by providing lateral flexibility in the suspension to reduce wheel camber change as the vehicle rolls. Directional tread noise has been brought pretty well under control by making the tread elements of different lengths so that the resulting tone is not sustained, but scrambled. Tire squeal levels have been lowered by softer tread stocks. Tire thump due to non-uniformity still persists despite correction of the non-uniformity, indicating that vehicles have probably become more sensitive. Tire roughness appears to be on the increase, but since accuracy in tire building seems to have reached its limit, further improvement must come from designing cars with less sensitivity.

(Based on secretary's report of Round Table on Noise Suppression in Passenger Cars held under auspices of SAE Passenger Car Activity at SAE Summer Meeting, Atlantic City, June 8, 1954.)

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Get Control of Costs When Output Fluctuates

C. L. BUSH,
The Oliver Corp.

CHANGES in volume of production make it more than ever necessary to establish some control over expense. And this is being done in most instances by use of a flexible or variable budget which is geared to some measure of plant production, such as direct labor or units made, and tailored to fit specific needs.

The flexible budget provides a helpful and necessary guide, but it does not obviate the need for using mature judgment, sound management decision, and the taking of a searching look at the question "how much can be afforded?"

Maintenance and tool room costs pose a real control problem when volume fluctuates because of the fixed nature of maintenance jobs. When there are large expenses such as major repairs they cannot readily be handled with a flexible budget geared to production. Special allowances must be made outside the regular budget.

Customarily a budget may be considered flexible and workable until planned production fluctuates up or

down more than one-third. When this extreme is exceeded, it is time to consider a new budget which takes into account large maintenance and tool room costs.

Changes in volume of production also call for proper evaluation of manpower needs, otherwise cost relationships will get out of control. Manpower budgets are hard to handle so rarely used. Large firms exercise control through dollar budget figures converted to manpower when necessary. Small firms can use job classification lists and adjust indirect labor with greater dispatch.

It is also true that manpower budgets are easier to handle when a single item is produced than where the product is diverse. In the latter instance, adjustment is usually made slowly through the workings of the flexible budget.

Control of technical and staff personnel is not to be achieved by a flexible budget. Skilled men are too hard to organize and train to be let go automatically in time of stress. Actually, that's the time they may be most needed. Here, one of the courses to be pursued is to face production and sales possibilities squarely. If the drop in output promises to be of long duration, a cut in personnel can be made. Otherwise the staff is usually carried in full force. Before taking action, management should make a searching review.

Those who adopt automation will find to their surprise that burden rates rise. This is axiomatic when direct labor goes down and overhead remains the same. Automation will raise fixed costs so that idle capacity becomes a heavy cost when volume falls. But, conversely, when volume rises, unit costs drop.

Anyone embarking on automation would do well to estimate carefully as the field has yet to be widely explored. The setting of burden rates calls for caution; too much waste has not proved out.

Some plants tie budgets and pricing together; some don't. If special budget allowances have been made over and above what the flexible budget and overhead dates allow, there will be trouble explaining why the budget was met but money lost. When activity falls below that used in pricing a product, these special allowances for fixed items of cost may help to cause a loss in profit, even though actual cost and budget allowances show a satisfactory relationship.

Keeping budget allowances fixed unless there is a change in selling price is one solution. A more common one is to make changes to meet special conditions or changes in output schedules. Then, when there is a loss in profit while the budget is met, an exact analysis of excess costs can be made.

Most concerns believe controllable

Members of the Panel

Panel Leader

B. F. Armbruster
The Oliver Corp.

Panel Secretary

C. L. Bush
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W. R. Bunge
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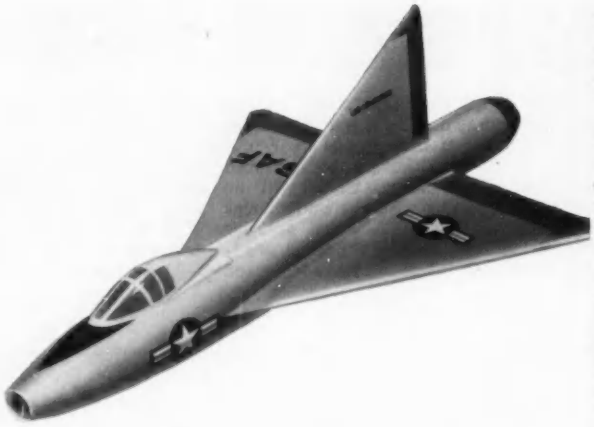

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It is, we believe, an "engineers" engineering department—interesting, energetic, explorative — with the diversity that means security for capable personnel.

As proof, consider this: Convair developed and flew the world's first turbo-prop airplane, first delta-wing airplane, first delta-wing seaplane — engineered and built the world's biggest transport, the world's safest high-performance commercial aircraft.

Or this: Convair's B-36 is the world's largest operational bomber, Convair's B-24 Liberator was World War II's most used heavy bomber, Convair's XP5Y-1 holds the world's endurance record for turbo-prop aircraft.

Or this: Convair has been awarded the nation's first production missile contract and the first production contract for supersonic interceptors.

Currently . . . Convair has the greatest diversity of aircraft engineering projects in the country, including high-performance fighters, heavy bombers, large flying boats, transports, trainers, seaplane fighters and guided missiles.

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Write: H. T. BROOKS, Engineering Personnel Department S-9

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figures should be furnished to all levels of operating supervision. It is also felt that foremen should be held responsible for results. In one plant, the foreman gets figures for productive labor efficiency and is held responsible for this alone. In other plants the foreman gets an entire budget sheet with all accounts it is felt he can control. Some tailor budget sheets along a functional line to fit cost centers; others fit to a responsibility accounting, and some mix the two.

It is one thing to give a foreman a budget and quite another to get him to use it as a tool of cost control. The incentive system is avoided because of the headaches potential in its administration. Preference goes to rewarding a good budget job through public recognition, a salary increase, or prize. A budget should let the foreman know what he can do under various levels of production without getting decisions from his superior. It should make the foreman into a business manager and provide him with concrete evidence of his status and its importance in the overall effort to operate in a satisfactory manner.

(The secretary's report of Panel on Manufacturing Expense Control and Manpower Scheduling on which this article is based is available in full in multilithographed form together with reports of seven other panel sessions presented at the SAE Production Forum, in Chicago, March 29, 1954 as publication SP-306, from SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers).

Airport Runways Can't be Elastic

Based on paper by

FRED M. GLASS

Aviation Dept., The Port of New York Authority

AIRPORTS can't continue to play leapfrog with the aircraft designer. They cannot continue to add a thousand feet of runway everytime the designer's slipstick turns out a new airplane. Those days are gone forever.

The cost of airport construction and the zoning requirements, the acquisitions, and the expansion of operations are such that when an airport is to be expanded and runways extended, and properties made larger, there will be more involved than a particular aircraft coming off the line which would like another 750 ft of runway.

Basic CAA standards establishing the lengths of runways, particularly for inter-continental airports, are in

effect now. These standards are the guides which will have to be followed in the design of all transports, jet included, at least for the foreseeable future.

By the same token, the old configuration of congential runways, or runways heading in every direction, are passe. Airports of the future will have one-directional or, at most, intersecting runways. Twin sets of runways with a 5000 ft separation strip is the pattern of the future. In time, as the art develops, these parallel runways will permit simultaneous landing and take-off. (Paper "The Airport Problems' was presented at SAE Southern California Section, Feb. 11, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

CLR Engine Provides Ideal Tool

Based on paper by

F. T. FINNIGAN

and

P. E. PFEIFER

The Pure Oil Co.

WE need laboratory engine cleanliness tests that will yield results consistent with field experience. This is indicated by the failure of extensive fleet tests of MIL-0-2104 approved crankcase oils to produce cleanliness results projected by the L-4 and L-1 tests.

Engine deposition studies emphasize the advantage of cycling through a variety of engine operating conditions as compared with the L-4 test. Cycling more nearly simulates field practice with corresponding similarity in engine deposition. Ratings based on test time to a common failure give more significant comparisons than a test of fixed duration, since they eliminate any speculation as to final outcome.

By using a series of separate techniques, it is possible to isolate the effects of many oil properties and deal with them independently. When an oil meets the rigid requirements of each individual test, it can be expected to give the same high performance in the field.

It would be desirable if one research type engine could be used to evaluate these individual properties critical to the engine — lube oil relationship. Then, perhaps a single test technique could be developed for evaluating a number of properties simultaneously, thus completing the cycle back to a limited number of recognized standard test procedures.

The timely appearance of the CLR

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Navy LCdr Francis X. Brady with Cougar, in which he broke transcontinental flight record April 1st, 1954—3 hours, 46 minutes, 49 seconds

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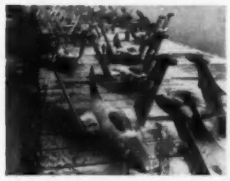
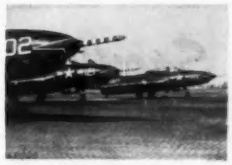
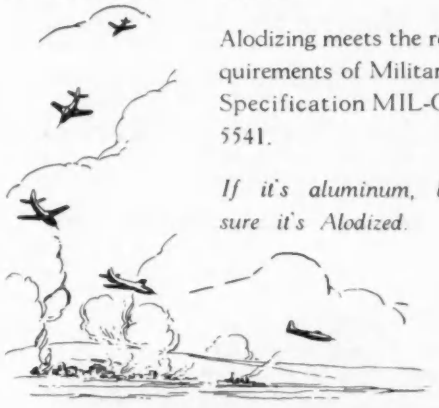


Snow-covered Panther Jets on flight deck of USS Philippine Sea prior to take-off.



Panther Jets on run-ways



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engine, designed specifically for maximum flexibility, provides an ideal tool with which to meet this challenge. (Paper "A New Approach to Crankcase Oil Development" was presented at SAE Summer Meeting, Atlantic City, June 9, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Studies Pinpoint Causes of Rough Ride

Based on report by

A. C. MAIR

Chevrolet Motor Division
General Motors Corp.

A TRUCK can and does bounce on a smooth road. It happens at certain critical speeds and the smoother the road the worse the vibration. The driver doesn't enjoy it and neither does the cargo.

The explanation for this phenomenon has been found to lie in tire and wheel runout. When tires were circularly ground, the vibration was stopped. Then, using ground tires, it was found that an unbalance as high as 150 in./oz did not produce the vibration, therefore, it was attributed to runout. It was also found that vibration increased after several thousand miles of use because the springs lost most of their lubricant and were inoperative for small movements. In other words, the forces caused by runout were not sufficient to exceed interleaf friction.

There are several ways to cure this ill, as follows:

1. Reduce inter-leaf friction by using fewer spring leaves.
2. Develop better spring lubricants and/or better means of retaining them.
3. Use frame reinforcements when frame bending is excited by wheel runout.
4. Reduce runout of tires and wheels in production.
5. Reduce runout in service by careful rim clamping and tire grinding (a fair remedy at a premium price).

The extreme differentials in weight between empty and loaded and the inherently high center of gravity of truck and payload create one of the biggest ride problems. The large high loads demand high spring rates to

provide sufficient roll stiffness and resistance to axle wind-up during brake application. If spring rates are to be lower to gain a better ride, radius or torque rods and stabilizers must be added to control axle wind-up and roll, all of which increase both initial and service costs. Some way must be found to keep these costs down and reduce the complications of construction if the cures are to be economically feasible.

(Based on secretary's report of Round Table on Riding Comfort in Trucks held under auspices of SAE Truck & Bus Activity at SAE Summer Meeting, Atlantic City, June 9, 1954.)

Contributors to Round Table on Riding Comfort in Trucks

Maurice Olley, Leader
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C. T. Kope
Ford Motor Co.

A. K. Simons
Bostrom Mfg. Co.

G. W. Tannahill
Chrysler Corp.

Get Generalities in School, Specialization from Job, Industry Tells Students

D. I. HALL
General Motors Corp.

INDUSTRY wants engineers who can think clearly, exercise judgment, and apply their learning to problems as they arise. The characteristics which the education system and the students themselves should develop are intellectual honesty, enthusiasm, tolerance and a desire to learn from the more experienced, willingness to tackle a job and see it through, ability to take criticism, and a humane attitude.

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On the Panel which developed the information in the accompanying article were:

H. C. Jones,
Panel leader
General Motors Corp.
D. I. Hall,
Panel secretary
General Motors Corp.
H. W. Brandt
General Motors Corp.
L. D. Conta
University of Rochester,
Division of Engineering
P. D. Hansen
University of Rochester
H. J. Loberg
Cornell University,
Sibley School of Mechnical Engineering
W. J. Magrattan
University of Rochester
G. C. Whitaker
Graflex, Inc.

view of what an engineering education should and can provide. In addition, it cautions against overspecialization, realizing the essential need for an engineer to be well-rounded and to be able to understand the problems of others. It realizes, too, that education is only begun when the college course is completed.

The colleges have been shifting their position, too. Time was when an engineering education was based on empirical rather than on rational methods. Curricula were concerned with practical courses, such as foundry and pattern making, surveying and drafting. All this is changed to keep pace with the changes in the need of the profession.

Today, more emphasis is put upon mathematics and basic science. This was the first change to be made. Then were added courses in the humanities and social studies. From practically nothing these courses have grown to occupy about 20% of the average college engineering curriculum. If this seems like a large proportion, we must remember the great stress industry places on the communicative skills. All these additions meant that something had to be omitted and that something was specialization.

Both industry and educators view curtailment of specialization with satisfaction. Educators believe more has been accomplished than simple omission. Their knowledge of engineering progress told them it was hopeless to train a specialist in four years. The specialties themselves have grown too fast and too voluminously. What was taught one year was outmoded the next. And the longer the student applied himself to a specialty the further behind he lagged. Furthermore, the

frontiers of the specialties are in industry and the time lag is too great for the colleges to stay in the vanguard.

What the student gets today in lieu of specialization is training in fundamental principles—in principles which apply to a variety of fields and which do not become obsolete rapidly. Although specialized courses remain in the curriculum, they have now become courses in which fundamental principles are relearned and applied. Educators hope the net result will be to turn out graduates who will have the initiative and self-reliance to continue their education on their own—who will buy a book rather than seek a course when faced with the task of learning in some new field.

Industry, educators, and students agree that most graduates do not know what work they want to pursue. This is another reason why specialization is unwise. Because they lack definite inclinations and skills for specific work, they tend to lack confidence in themselves. This seems to be the weak link in an otherwise fairly strong chain.

We might put this another way by saying that the transition from college to industry is the weak point. But what to do about it? Students think the answer is more practical experience during the undergraduate years. Summer work in industry might be one solution. This would provide an opportunity to get the feel of industry and to build a sense of adequacy.

Both industry and educators consider valid the student's desire to become acclimated at the earliest possible moment. And they have done something about it. Cooperative programs have been set up between college and industry. Here the student may work one year while studying, the time being taken out of various college terms. Some concerns make a point of putting graduates through a sort of training year, thus giving a man the chance to gain a variety of experiences to help him settle upon some specific type of work.

It does seem important that the work students get while in college should challenge their minds and give them the widest possible experience. This is not always easy for industry to offer. Industrial projects have definite timetables which may not coincide with the time the student has available. If assigned to such a project he may not be able to get in at the start or stay through to the end. His worth to industry is thereby reduced and he may not get a chance at something real and challenging.

On this problem, however, industry and the colleges are drawing closer together. Post-graduate training programs are on the increase and this may be the ultimate solution.

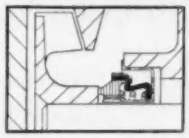
(Based on secretary's report on Education and Industry Forum held at a meeting of the Rochester Division, SAE Buffalo Section, Feb. 17, 1954.)

3 REASONS WHY DESIGN ENGINEERS PREFER THESE THREE JOHN CRANE "PRESSED-IN" SEALS

✓ Quickly Installed
✓ Extremely Compact
✓ Low in Cost

STATIONARY SEALING HEAD TYPE 11-A

A. Seal Retainer.
B. Synthethic Rubber Bellows.
C. Metal Band.
D. Spring.
E. Holding Dents.
F. Precision-Lapped Sealing Washer.



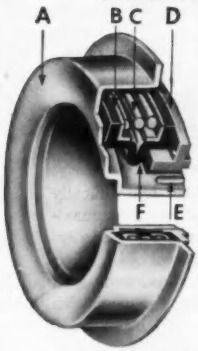
This pressed-in packaged sealing unit is designed with the spiral steel spring inside of the synthetic rubber bellows to protect it against corrosion.

The spring clamps the flange of the bellows tight against the bottom of retainer and the metal ferrule squeezes the top portion of the bellows against the "Teeplelite" washer.

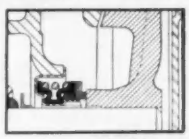
This liquid-tight seal is especially recommended for small shafts on *hot or cold water, oil, gasoline, kerosene, soapy water.*

Use this seal on: *Low Pressures* to 35 PSI
Temperatures —65°F. to +220°F.

STATIONARY SEALING HEAD TYPE 6-A



A. Seal Retainer.
B. Metal Ferrules.
C. Spring.
D. Precision-Lapped Sealing Washer.
E. Holding Dents.
F. Synthetic Rubber Bellows.

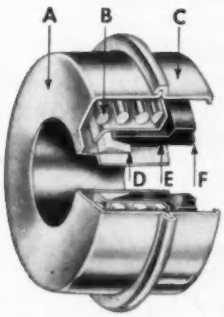


This pressed-in packaged sealing unit is designed with a spiral steel cadmium plated spring (stainless or bronze optional) assembled between two metal ferrules which clamp the flanges of the synthetic rubber bellows tightly against the retainer shell and the "Teeplelite" washer.

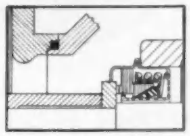
This liquid-tight seal is especially recommended for small shafts on *hot or cold water, oil, gasoline, kerosene, soapy water.*

Use this seal on: *Medium Pressures* to 75 PSI
Temperatures —65°F. to +220°F.

STATIONARY SEALING HEAD TYPE 9-A



A. Seal Retainer.
B. Spring.
C. Sleeve.
D. Wedge of Teflon.
E. Sealing Washer.
F. Precison-Lapped Face.



This pressed-in packaged sealing unit is designed to use a wedge sealing ring of Teflon*. This wedge shaped sealing ring closely fits the inner sleeve of the retainer and makes a liquid-tight contact with cone surface of carbon washer.

The result is a liquid-tight seal which is especially recommended for *hot oil, and all chemical liquids or gases, hot or cold.*

Use this seal on: *High Pressures* to 150 PSI
High Temperatures +485°F. *Low Temperatures* —120°F.

Write for fact-filled catalog. Crane Packing Company, 1819 Belle Plaine Ave., Chicago 13, Ill.

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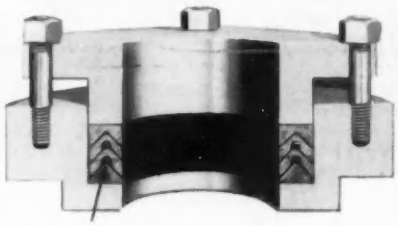


Note the exclusive hinge-like construction of CHEVRON packing.

Garlock 431 CHEVRON Packing

GARLOCK CHEVRON Packing is entirely different from ordinary V-type packings. With *increasing* pressures CHEVRON rings tighten and prevent leakage; with *decreasing* pressures the packing eases off and permits operation with a minimum of friction.

Service reports, such as those below, prove that CHEVRON packing seals better and lasts longer.

▶ On hydraulic press—40″ ram, 6,000 p.s.i., ram honed and chrome plated, gland machined to give clearance of .006″ between gland and ram. Garlock 431 CHEVRON size 40″ x 41½″ x only 2″ deep gave 14 years service.

▶ On a machine with hydraulically operated clutches—¾″ cylinder, maximum pressure 500 p.s.i., service intermittent, maximum travel ¾″. First used cups, then "O" rings, neither of which worked well. Now packed with Garlock 431 CHEVRON ⅜″ x ¾″ x $\frac{17}{32}$″ deep and doing a smooth, positive sealing job.

Ask your Garlock representative to give you all the cost-saving facts about CHEVRON packing, or write for folder AD-115.

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

Sales Offices and Warehouses: Baltimore • Birmingham • Boston • Buffalo • Chicago • Cincinnati • Cleveland Denver • Detroit • Houston • Los Angeles • New Orleans • New York City • Palmyra (N.Y.) • Philadelphia Pittsburgh • Portland (Ore.) • Salt Lake City • San Francisco • St. Louis • Seattle • Spokane • Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

*Registered Trademark

GARLOCK

PACKINGS, GASKETS, OIL SEALS, MECHANICAL SEALS
RUBBER EXPANSION JOINTS

New Members Qualified

These applicants qualified for admission to the Society between July 10, 1954 and August 10, 1954. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Group

Grant F. Jackson (M).

Baltimore Section

Richard Frederick Depkin (J).

Buffalo Section

Arthur S. Irwin (M), Matthew L. Lester (A), Gordon E. Peterson (J), Matthew L. Spitzer (J), Robert A. Witte (M).

Canadian Section

John Bonfield (M), Oreland McIntyre (A), Stanley Wallace (A).

Central Illinois Section

Duane Elwyn Evans (J), Dean D. King (M), Wayne E. Pierson (A), Richard Glenn Warner (J).

Chicago Section

Calvin K. Agger (A), Russell F. Denney (M), Leonard C. Ganderton (M), John C. Hanna (M), Clarence E. Killebrew (M), Eugene B. Raymond (M), David L. Stevenson (A), John Thayer (J), Mrs. Willow E. Wilcox (A), J. V. Woolley (J).

Cincinnati Section

J. D. Graham (M), John A. Schreibeis (A), Kenneth W. Stalker (M).

Cleveland Section

William C. Eaves (M), Richard H. Gardner (J), John J. Goodill (M), Arthur James Hepler (A), Raymond P. Michnay (J), Elmer P. Orvis (M), Thomas A. Robertson (M).

Colorado Group

Hugh Caughey (M).

Dayton Section

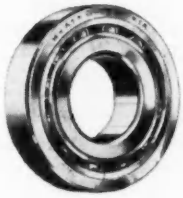
J. A. Lawler (M), Joseph T. Morris (M), Kenneth Parker (J), George A. Vogel (M).

Detroit Section

George C. Aitken (M), Charles S. Ashbrook, Jr. (A), Paul C. Bailey (A), Ritchie S. Barrie, Jr. (J), Kenneth John Biel (J), Stanley Bobola (A), Samuel G. Brady (M), Charles P. Burr

Gas-Turbine-Powered Pump on Test at Navy Fire Fighting School

Where Hyatts turn at 40,000 rpm!



Old in theory, gas turbines are comparatively new as a practical power source. So it was big news in engine development when Solar Aircraft Company, of California, announced the world's first portable, hand-started gas turbine power plant.

Developing 50 horsepower, the new lightweight operates at the high speed of 40,000 rpm—or twenty times the speed of most automobile engines! And that's where *we* come in.

To be sure of complete bearing dependability for such high-speed operation, Solar turned to Hyatt . . . and there's a Hyatt Hy-Load Roller Bearing at the most critical position on the turbine shaft.

Whether you're building locomotives or lawn mowers, and whether shafts turn at 4 or 40,000 rpm, you'll get better bearing performance from *Hyatts!*

HYATT

ROLLER BEARINGS

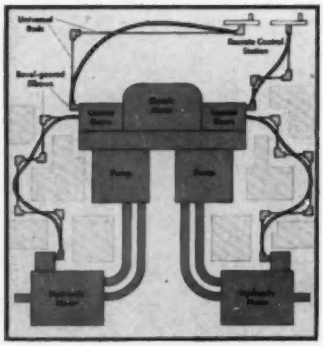
STRAIGHT BARREL TAPER

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

COST-SAVING IDEAS FOR DESIGN ENGINEERS

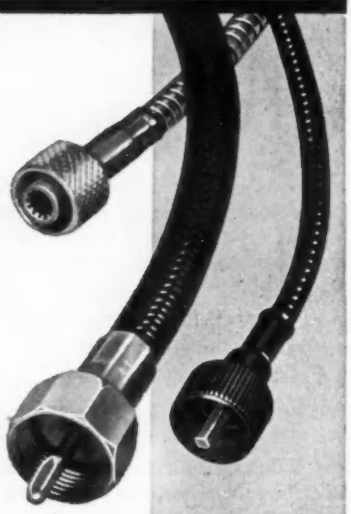
FOUR
S. S. WHITE FLEXIBLE SHAFTS
REPLACE 35 PARTS
...CUT COSTS 90%

Only 4 S.S.White flexible shafts were needed to control the dual hydraulic system illustrated. They replaced 17 universal rods with their bearings and 18 bevel-geared elbows. The shafts cost only 1/10 as much—they substantially reduced assembly time and labor—eliminated all alignment problems—and provided a degree of sensitivity that was impossible to obtain with the former arrangement. The result: a 100% improved application at a fraction of the original cost!



SAVE TIME, TROUBLE and EXPENSE

When you have a mechanical remote control problem, it's good, sound practice to give first consideration to S.S.White flexible shafts. Their many money-saving advantages offer unlimited opportunities to cut costs and to improve your equipment.



BULLETIN 5306 gives details on how to select and apply flexible shafts. Send for your copy. Address Dept. J.

R-3

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
10 East 40th Street
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

New Members Qualified

continued

(A), Edgar W. Caldwell (M), Norman B. Christie (M), James R. David (J), Robert E. Day (M), Joseph W. Fargo (A), Robert Orrin Field (M), Edward Fischer (M), Edward P. Francis (M), Donald Nelson Frey (M), Walter Gibbs, Jr. (A), Allen F. Gifford (A), C. James Hail (M), Oliver R. Halonen (M), Richard Edward Henrich (M), Walter Richard Holm (A), George E. Hooton (J), Bernard C. Hudgens (M), Louis Liggett Hunt (M), James A. Joyner (M), Stanley A. Kaye (A), Gerald Klaasen (M), Joseph P. LaGore (A), William V. Luneburg (M), Lawrence E. Miazga (M), G. E. Muma (M), Reno Offringa, Jr. (J), William Carl Ohmer, Jr. (A), J. H. Palmer (A), Donald J. Peeps (M), Joseph Pickles (M), Manny Robert Richards (A), Charles Noel Richardson (J), Albert O. Rominsky (J), Frank F. Rycamber (A), Earl J. Scanlon (A), R. M. Smiley (A), Robert George Tessmer (J), George Thomas Timoff (J), Lewis E. Tolan (J), Robert Frank Wood (J).

Indiana Section

George A. Bretzlaff (M), James A. Nelson (M).

Kansas City Section

R. H. Beymer (A), James R. Johnson (A), Charles J. Middleton (J).

Metropolitan Section

Thomas Harrison Dooley (M), Francis A. C. Eisele (A), G. Lawton Johnson (M), William W. Milne (A), Thomas E. Richard (M), Donald Philip Walker (J).

Mid-Michigan Section

Robert H. Daley (A), David P. Smith (A), Bryce L. Stevens (J).

Milwaukee Section

W. W. Bigelow (M), Clyde Kuhlman (A), Robert George McIndoo (J), David J. Munroe (M), John W. Poulter (M), Eugene F. Tiefenthaler (A).

Mohawk-Hudson Group

Jack M. Delfs (M).

Montreal Section

John Peter Fullam (M), Armand Grenier (M), G. Harrison (M).

Included in the Air Data provided by an AiResearch System are—TRUE AIRSPEED • FUNCTIONS OF MACH NUMBER • TRUE DYNAMIC PRESSURE • DENSITY ALTITUDE • INCREMENTAL MACH NUMBER • INCREMENTAL ALTITUDE • RATE ALTITUDE TRUE ANGLE OF ATTACK • TRUE ANGLE OF YAW • ROCKET JUMP ANGLE • ROCKET MUZZLE VELOCITY TRUE STATIC TEMPERATURE • ENGINE PRESSURE RATIO • MECHANICAL ADVANTAGE SHIFTER CRUISE CONTROL COMPUTER • SUPERSONIC INLET COMPUTER CONTROL • BALLISTICS COMPUTER

X-ray a modern jet airplane and you'll find some kind of data gathering equipment to aid pilots in accurately delivering fire power.

AiResearch engineers have conceived *complete* systems of this kind. They are called Central Air Data Computer Systems—integrating pneumatic, electrical and electronic components. These systems sense, measure and correct *automatically* for all air conditions affecting flight.

The combination of transducers, computers, and indicators constitutes the simplest and most reliable system for gathering and interpreting air data. AiResearch has the skills and years of experience to create such *complete* systems for any type of aircraft.

Also, if you have a problem involving equipment for temperature or pressure control, remote positioning, synchronizing, or analogue computing, consult AiResearch now.

AiResearch Manufacturing Company

A division of **THE GARRETT CORPORATION** *Los Angeles 45, California • Phoenix, Arizona*

Designers and manufacturers of aircraft components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS

New Members Qualified

continued

New England Section

Warren L. Ellis (A), Budd Lynn Kehne (A).

Northern California Section

Thomas Adolph Golden (J), Kenneth D. Lewis (M), Walter Anthony O'Brien (M), Glenn D. Seaman (A.)

Oregon Section

S. L. Jackson (A).

Philadelphia Section

James F. Armstrong (A), John A. Jackson, Jr. (A), Floyd J. Sisto (M).

St. Lous Section

George E. Mallinckrodt (M), Rudy F. Schneller (M).

Salt Lake City Group

Calvin Warner Dunbar (J).

San Diego Section

Howard G. Engler (A), E. S. Oppenheimer (A), Jack C. Thompson (A).

Southern California Section

Everett H. Badger (M), Clair R. Baker (M), Robert Royer Bloom (J), James B. Cooper (M), Thomas E. Davidson (M), Harry A. Faris (A), Johannes S. Newton (M).

Southern New England Section

Frederick R. Schollhammer (J).

Spokane-Intermountain Section

Orville Blaze Isaacs (A).

Texas Section

R. C. Howren (A).

Virginia Section

Carmine Lattanze (M).

Twin City Section

Everett A. Hansen (M), Donald Frederick Titus (A).

Washington Section

Fanning Miles Baumgardner (M), Thomas K. Tamashiro (J), Theodore F. Trimble (J).

Western Michigan Section

William McGarvey (J), E. R. Nelson (A).

Outside Section Territory

Ben Burkart (M), John J. Dorwin (M), Elliott A. Johnson (A), Charles S. Morrison (M), William E. Splinter (J).

Foreign

V. Gopalan (J), India; Gopalkrishna Ganapathy Kudva (J), So. India; Hans-Eric Lorentz (J), Sweden; Mohamed Sharker Mohideen (M), Ceylon; Adolf Von Euw (M), Mexico.

BIGGEST SELLER

because it's the BEST PERFORMER!

You're looking at the most widely accepted Air Brake Compressor ever produced for the truck and bus industries—a rugged, reliable Bendix-Westinghouse compressor. This precision-built reciprocating piston compressor is a dependable, long-lived unit which over the years has rolled up *more miles on more installations* than any other compressor ever built. That's mighty important to you. And whether you build, sell or operate trucks or buses, you can put this same unequalled experience to work for you. For into every Bendix-Westinghouse product, from compressors and brake valves right on down to brake chambers and slack adjusters, goes the manufacturing and design know-how gained through more than 30 years of continued leadership in the Air Brake business. That means better, safer, more efficient braking performance on any hauling or transit job. Take advantage of it—be sure your vehicles are equipped with the very best in brakes. Always specify Bendix-Westinghouse—The World's Most Tried and Trusted Air Brakes.

Bendix-Westinghouse

THE WORLD'S MOST TRIED AND TRUSTED **AIR BRAKES**

BENDIX-WESTINGHOUSE AIR BRAKES REG. U.S. PAT. OFF.

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE CO.

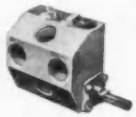
General Offices & Factory—Elyria, Ohio
Branches—Berkeley, Calif., and Oklahoma City, Okla.

NEW STANDARDS OF PERFORMANCE FOR AIRCRAFT

ADEL AN APPROVED HYDRAULIC EQUIPMENT

ADEL TYPICAL 3000 AND 1500 PSI, NON-INTERFLOW 4-WAY DISC TYPE SELECTOR VALVES

AN6293-4, -6 and -8



ADEL TYPICAL 1500 PSI, 4-WAY POPPET TYPE DIRECTIONAL CONTROL VALVES

AN6210-1 and -2, AN6211-1 and -2

New designs are more compact, have low weight, longer service life, less maintenance, easy installation characteristics plus *proven operating efficiency.*

Compare this outstanding hydraulic equipment with any other and see for yourself why ADEL units are unexcelled for high pressure performance in aircraft hydraulic applications.

HYDRAULIC AND PNEUMATIC CONTROL EQUIPMENT • HEATER, ANTI-ICING AND FUEL SYSTEM EQUIPMENT • ENGINE ACCESSORIES • LINE SUPPORTS.

Write for new, descriptive Brochure containing detailed information on ADEL'S line of Aircraft Equipment and facilities. Address ADEL DIVISION, GENERAL METALS CORPORATION, 10783 Van Owen St., Burbank, Calif.

ADEL TYPICAL 3000 AND 1500 PSI, SHUTTLE VALVES—AN APPROVAL ON ALL DASH NUMBER VARIATIONS

AN6209, AN6217, AN6277 and AN6278

ADEL TYPICAL 3000 PSI, ADJUSTABLE, POPPET TYPE RELIEF VALVES

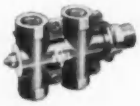
AN6279-4, -6 and -8

ADEL TYPICAL 1000 TO 2100 PSI CRACKING PRESSURE, THERMAL RELIEF VALVES

AN6245A4

ADEL TYPICAL 1500 PSI, POPPET TYPE CHECK VALVES

AN6247-2



ADEL TYPICAL 1500 PSI, ADJUSTABLE, PISTON TYPE RELIEF VALVES

AN6200-8AB and AN6200-6AB

ADEL LEADER IN AIRCRAFT EQUIPMENT

DIVISION OF GENERAL METALS CORPORATION • BURBANK, CALIF. • HUNTINGTON, W. VA.

CANADIAN REPRESENTATIVE: RAILWAY & POWER ENGINEERING CORPORATION, LIMITED.

Applications Received

The applications for membership received between July 10, 1954 and August 10, 1954 are listed below.

Atlanta Group

Leo Droughton, Jr.

Baltimore Section

William C. Roben.

British Columbia Section

Neil S. McKechnie.

Buffalo Section

Walter Harold Bergler, Jr., Norman Charles Schlegel, Jr., William C. Warren III.

Canadian Section

Leo J. Butticci, Alfred James Coventry, Vernon Floyd Elliott, Donald C. MacKenzie.

Chicago Section

Arthur C. Achterberg, John L. Bemesderfer, Franklyn B. Fullmer, John A. Halgren, Herbert K. Holm, John A. Lake, R. L. Larson.

Cincinnati Section

Edward Glodeck.

Cleveland Section

Allen Horton Bassett, Jr., Robert J. Fay, Raymond F. Hana, Gerhard A. Hauser, Thomas Osters, Victor C. Schroeder, Jr., Arthur E. Stukey, Charles J. Wallace, B. C. Yearley.

Colorado Group

Joseph T. Keeley.

Dayton Section

James Pearce Munroe, Robert A. Rodgers.

Detroit Section

Richard B. Atherton, N. George Avram, Richard E. Bradfield, Robert Gerald Brown, J. Lawrence Buell, Jr., William Campbell, Robert J. Chapman, Forrest R. Cheek, Lloyd F. Curby, George H. Elsner, Thomas J. Feaheny, Frederick A. Hagen, David J. Hlubek, Paul R. Johnson, William F. Lomas, Joseph F. Macura, George H. Moore, A. C. Norris, William E. Oram, Robert C. Penn, Forrest Kenneth Poling, Henry M. Porter, Richard L. Reid, Robert William Reinhardt, Chester J. Selden, Karl Schwarze, Gordon Leslie Walker, John Withrow.

Hawaii Section

Harrie Edwin Hoxie, Jr.

LOOK TO

PIERCE — THE MARK OF QUALITY

for precision and production parts and assemblies

Pierce, creator of famous Pierce Governors and other fine engine control mechanisms, gives you the benefit of more than 40 years' experience as an important supplier to the automotive industry.

Two modern, fully equipped Pierce plants are available for production of component parts . . . fabrication, precision machining, production machining and assembly . . . to your exact specifications. Capable assistance on experimental projects also is available if desired.

Look to Pierce for Quality, Precision and Satisfaction! Your inquiry will receive our immediate attention.

Ask for new Pierce brochure,
"40 Years of Manufacturing Precision Controls"

PIERCE — THE MARK OF QUALITY

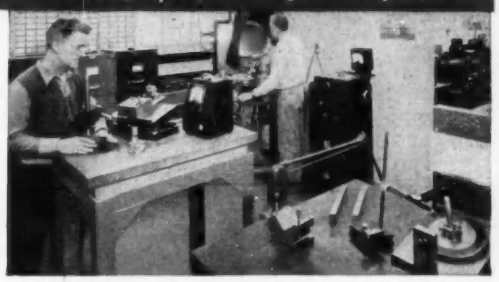
THE PIERCE GOVERNOR CO., INC.
1604 OHIO AVENUE
ANDERSON, INDIANA

Precision grinding, honing and lapping holds some dimensions to .000040"

Complete facilities for high production of machined parts

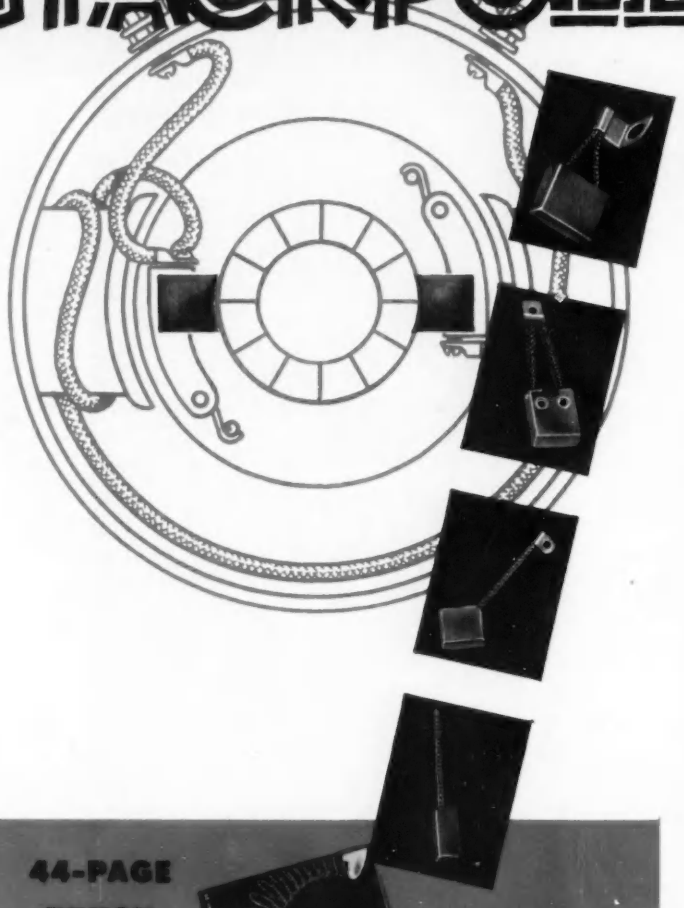
Equipped and manned for wide variety of assembly operations

Pierce Quality assured by finest testing and measuring equipment



The name that has signified small motor and generator brush progress and reliability since the earliest days of the industry.

STACKPOLE



44-PAGE BRUSH DATA BOOK

Write on company letterhead for Stackpole Brush Data Book #20

Address:
STACKPOLE CARBON COMPANY
St. Marys, Pa.

Brush and Contact Headquarters for over 40 years

Applications Received

continued

Indiana Section

Virgil L. Alexander, Emil Suchy, George Edward Thompson.

Kansas City Section

Frank G. Schmidt, Jr.

Metropolitan Section

Brian Casey, David Paul Fischer, William T. Gunn, Daniel W. Kaplan, Vincent R. LaVigna, Charles John Malone, William Vincent Oakenell, Edward T. Otte, Temple Chapman Patton, Robert C. Rame, Claude W. Stewart, Kenneth Willrich, James A. Wilson, Lewis A. Winkler.

Mid-Continent Section

Wendell R. Dieman, Robert Paul Stuart.

Mid-Michigan Section

Charles Hudson Butcher, Jr., Robert E. Fisher, John F. Sellinger.

Milwaukee Section

John P. Kuly, Robert H. Reineck, Matthew J. Wenner, Robert C. Wiczynski.

Mohawk-Hudson Group

Loren P. Neff.

Montreal Section

H. W. Drescher, Lachlam Macdonald Long.

Northern California Section

Ben M. Darrow, James M. Duffin, Walter James Eager, Jr., Neal Pardee Kirkham, Earl G. Koehler, John Kenneth Longmuir, Caspar J. Szukalski, Jr.

Northwest Section

James Ross Brown.

Oregon Section

Richard William Boubel, Loren Dean Gardner, Sheldon D. Hegg, R. A. Hutchison, Earl J. Klinemann, Donald Duncan Laine, William E. MacDonald, Howard Ernest Ostrin.

Philadelphia Section

Kenneth Frederick Becker, Richard Alan Hoffman, Frank A. Van Hoy, Otto F. Licht.

St. Louis Section

Myron Tygar.

Applications Received

continued

San Diego Section

James E. Belden.

Southern New England Section

Edward A. Avery, David John McGregor, Daniel N. McNally, Harry Leonard Stiegler, George T. Velz, Clifford Henry Wells, Sterling B. Withington.

Southern California Section

Fred K. Al-Khudairy, Charles R. Allen, Ralph Earl Cornwell, Jr., Ollie R. Harrison, Seiji Kami, Wilford P. Lakin, Walter E. Leser, Donald Richard Montgomery, Rodney K. Moore, Loren A. Patrick, Andrew C. Sherwin, Bert N. Svenson, F. F. Vaughan, William Albert Wilson.

Syracuse Section

Nathan P. Hughes, Reymont Szeliga.

Salt Lake Group

Fred L. Sommercorn.

Spokane-Intermountain Section

June Roberts.

Texas Section

Russell H. Biegel, Igor Alexei Black, Merle C. Mueller.

Texas Gulf Coast Section

Donald M. Buch.

Twin City Section

Lester D. Savage, Jr.

Western Michigan Section

Earl Dean Allen.

Williamsport Group

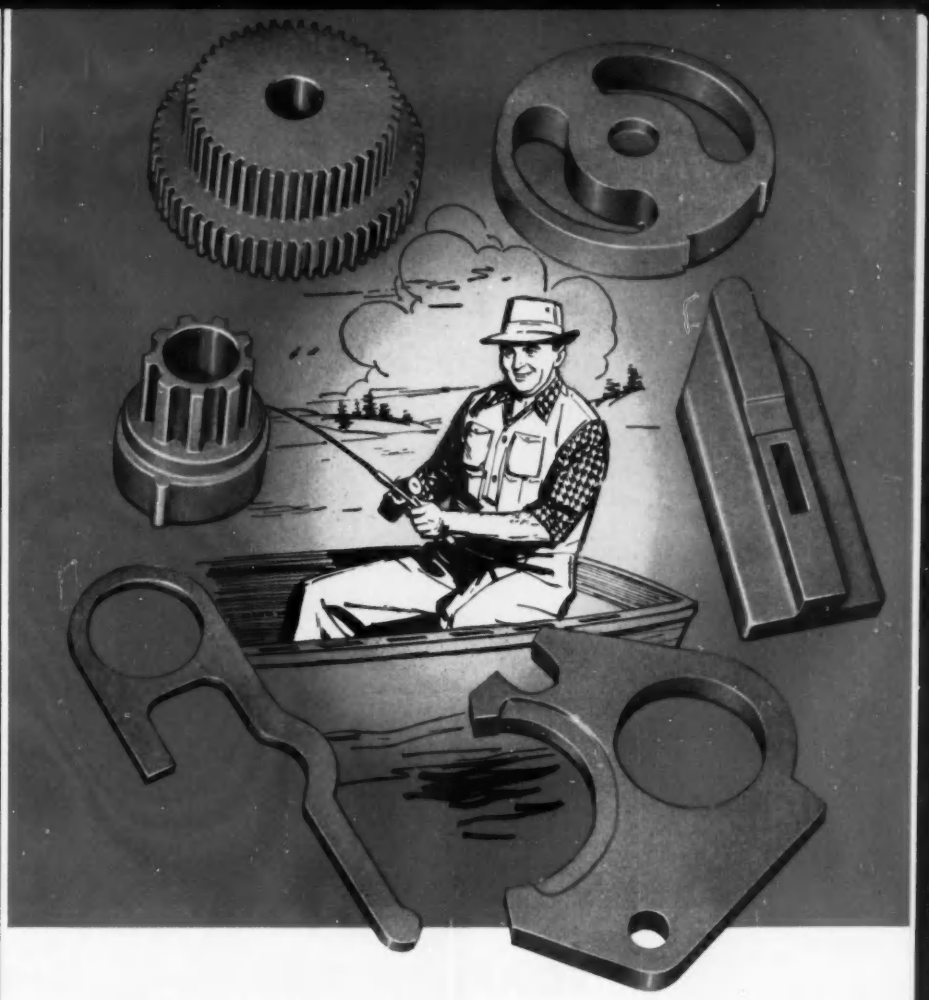
C. Frank Pannebaker.

Outside of Section Territory

James L. Bomberger, Louis P. Cosgrove, J. L. Fairchild, John S. Gabel, John G. Hoffman, Jr., Edwin Frank Humpal, Jr., Virgil J. Palub, James A. Stochl, Arnold W. Wolfgong.

Foreign

Ferruccio Accardi, Italy; Pushkaraj Lilaram Ballaney, India; Kshitindra Kanta Ganguli, India; David Vere Goland, Australia; Marcos Hadjes, Brazil; Raymond Nivet, France; John Ian Simcock, England; Kiyoshi Yamoto, Japan.



OILITE® Finished Machine PARTS

make your job EASIER... give you BIG SAVINGS too!

- Originators of Finished Machine Parts of Metal Powders
- Vast Research and Engineering Facilities
- Huge Production Facilities
- Each Part an Engineered Product
- COST is less, of course
- Fast Delivery... Normally 1 to 4 weeks
- Permits NEW Designs
- Large Parts, too—Over 20"
- ON-the-SPOT Service by Experienced Field Engineers

However you enjoy your leisure moments . . . fishing, gardening or just sittin' . . . it's more fun if your mind is free of "Shop" headaches. And that's why we're suggesting that you explore your designs for additional OILITE Finished Machine Parts applications.

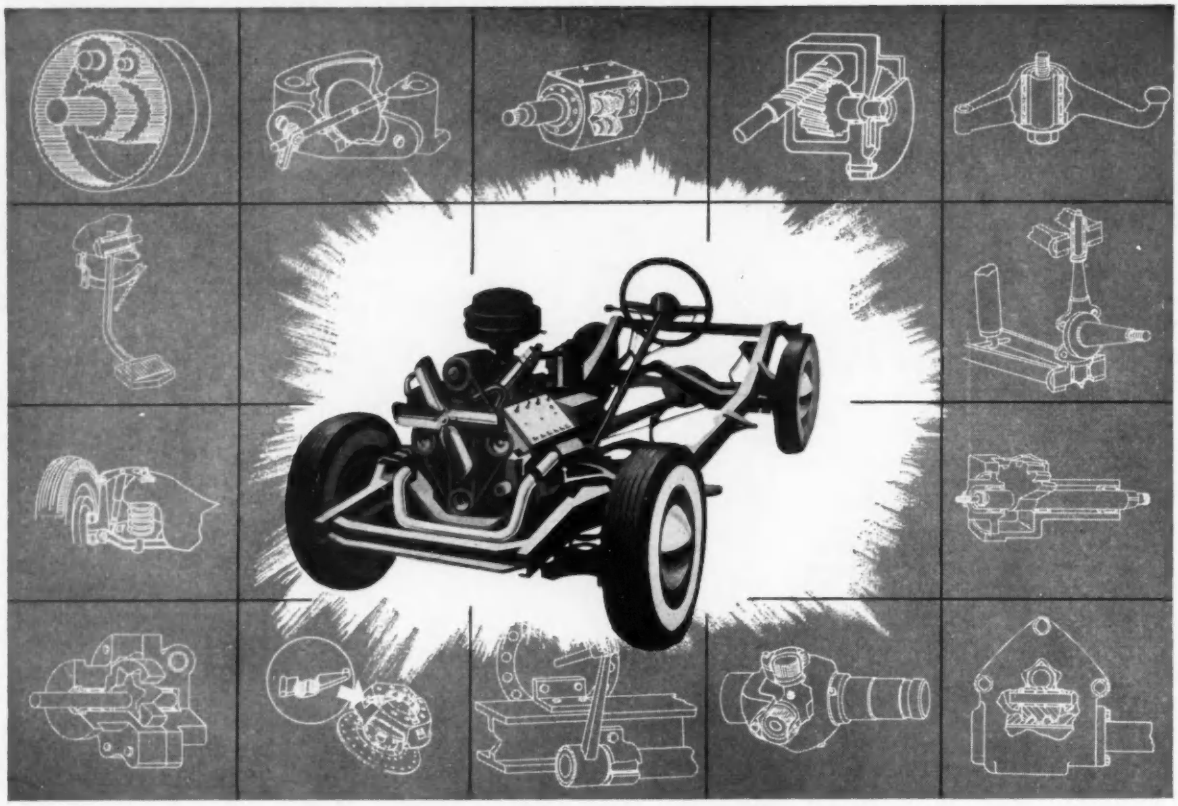
Each OILITE Part is an ***Engineered*** Product—Precision Made by artisans with more than 20 years Know-How. Field Engineers, too, give you ***ON-the-SPOT*** Service.

Only Amplex makes OILITE

CHRYSLER CORPORATION
AMPLEX DIVISION
Dept. Q-9 Detroit 31, Michigan

Field Engineers and Bearing Depots Throughout United States and Canada

OILITE Products include: Bearings, Finished Machine Parts, Cored and Solid Bars, Permanent Filters and Special Units of Non-Ferrous and Ferrous Metals and Alloys.



TORRINGTON Needle Bearings offer the Automotive Manufacturer these advantages

1. High capacity
2. Small size
3. Low cost
4. Ease of installation
5. Long service life

The automotive industry was one of the first to see the unique advantages of the Torrington Needle Bearing when it was introduced nearly twenty years ago. Today, leading manufacturers of automobiles, trucks and components have standardized on the Needle Bearing to such an extent that it is in use in almost every rotating or oscillating bearing application where compactness, high capacity and ease of installation are important.

The NEEDLE BEARING has been "Performance Proved" in these Major Applications

Universal joints · Governors · Steering gear rollers Steering knuckles · Steering idlers · Power steering Suspensions · Brake camshafts · Brake and clutch linkage pivots · Clutch throw out fingers · Transmissions · Hydraulic pumps · Window lifts *and many others.*

If some of these applications of the Needle Bearing are new to you, why not let our Engineering Department show you how they can improve the design and performance on your product? See your Torrington Bearing representative or write direct.

THE TORRINGTON COMPANY
Torrington, Conn. · South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

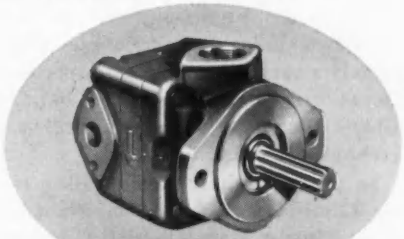
"Caterpillar" No. 41 Hydraulic Control imparts increased versatility to "Caterpillar" D2 and D4 Diesel Tractors. Here a D4 Tractor and tool bar with ditcher attachment is making irrigation ditches.

"CATERPILLAR" uses VICKERS HYDRAULIC PUMPS

"Caterpillar" selected the Vickers Pump (shown below) for the source of power in the No. 41 Hydraulic Control because of its outstanding performance . . . performance that results from several exclusive features. This Vickers Pump is vane type, hydraulically balanced and has automatic wear compensation. This means that it delivers more oil while taking less power from the engine . . . that it has a much longer life with minimum maintenance . . . and that it insures dependability and easier cold weather starting of the tractor. A Vickers Pump is the mark of high quality in hydraulic power controls.

6980

This is the Vickers Pump used in the "Caterpillar" No. 41 Hydraulic Control. Hydraulic systems on tractors and other farm equipment use more Vickers Pumps than any other make.



People who look for quality in tractors and farm equipment also look for VICKERS

VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1440 OAKMAN BLVD., DETROIT 32, MICH.

Application Engineering Offices: • ATLANTA • CHICAGO AREA (Brookfield) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) PITTSBURGH AREA (Mt. Lebanon) • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • TULSA • WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

When Should Alloy Steels Be Ordered to Hardenability?

This is the fifth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

What is hardenability and how does it differ in carbon and alloy steels?

Hardenability can be defined as the capacity of steel to develop a desired degree of hardness, usually measured in depth. It is produced by special heating and cooling. Carbon steel, except in small sections, will normally harden to a depth slightly below its surface, while alloy steel can, under certain conditions, harden uniformly through its entire cross-section.

Surface hardness obtainable after quenching is largely a function of the carbon content of the steel. Depth hardness, on the other hand, is the result of alloying elements and grain size, in addition to the carbon present in the steel.

In general, where hardenability is the prime consideration, it is not too important which alloy steel is used, just as long as there is sufficient carbon present to give the prescribed hardness, and enough alloying elements to quench out the section. We might mention here that it is not considered good practice to alloy a small section excessively, since too free a use of alloying elements adds little to the properties and can, in some instances, induce susceptibility to quenching cracks.

There are, of course, numerous cases where factors other than hardenability must be considered; such factors as low-temperature impact, heavy shock, creep-resistance, and the ability to resist temper brittleness. Through-hardening, therefore, is not always desirable. For example, shallow hardening is often necessary in shock applications, because a moderately soft core is essential.

Our metallurgists will gladly explain where it is advantageous to order alloy steels to hardenability, and where it is preferable to order by analysis. They will also give you any help you may require in connection with heat-treating and machining problems.

And when in need of steels, remember that Bethlehem manufactures the entire range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades. We can meet your needs promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM ALLOY STEELS

BETHLEHEM STEEL

Eaton Self-Contained Air Brake provides important performance advantages

The new Eaton SELF-CONTAINED air brake offers a number of outstanding advancements over other truck brake designs. For a given input greater braking effort is delivered at the drum. Compact, close-coupled design, combining a strong rigid chamber bracket mounted directly on the brake spider and a short camshaft supported entirely in the chamber bracket, provide reduced bracket deflection, reduced camshaft wind-up, and shorter required chamber stroke resulting in quicker truck stops.

Simply constructed with fewer parts, over-all weight is reduced approximately 15%. Advanced floating split-shoe design using a single pin at the anchor end and trunnion type rollers and pins at the cam end of the shoe eliminates the need for anchor-pin lubrication, makes for quick action and quick release and prevents pin seizure. Exhaustive tests show important increases in lining life—as much as 100%.

Overhauls are required less frequently, and when necessary, service time is reduced greatly, cutting labor as much as 2 to 4 hours per job.

Greater braking efficiency

•

Quicker acting

•

Quicker releasing

•

Longer lining life

•

Quick, easy reline

•

EATON — AXLE DIVISION — MANUFACTURING COMPANY

CLEVELAND, OHIO

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

6

Our modern plants

in six separate locations

give you a stabilized, dependable

source for sleeve bearings

and bushings—

and the finest engineering and

field service in the industry is yours

at our sales offices in

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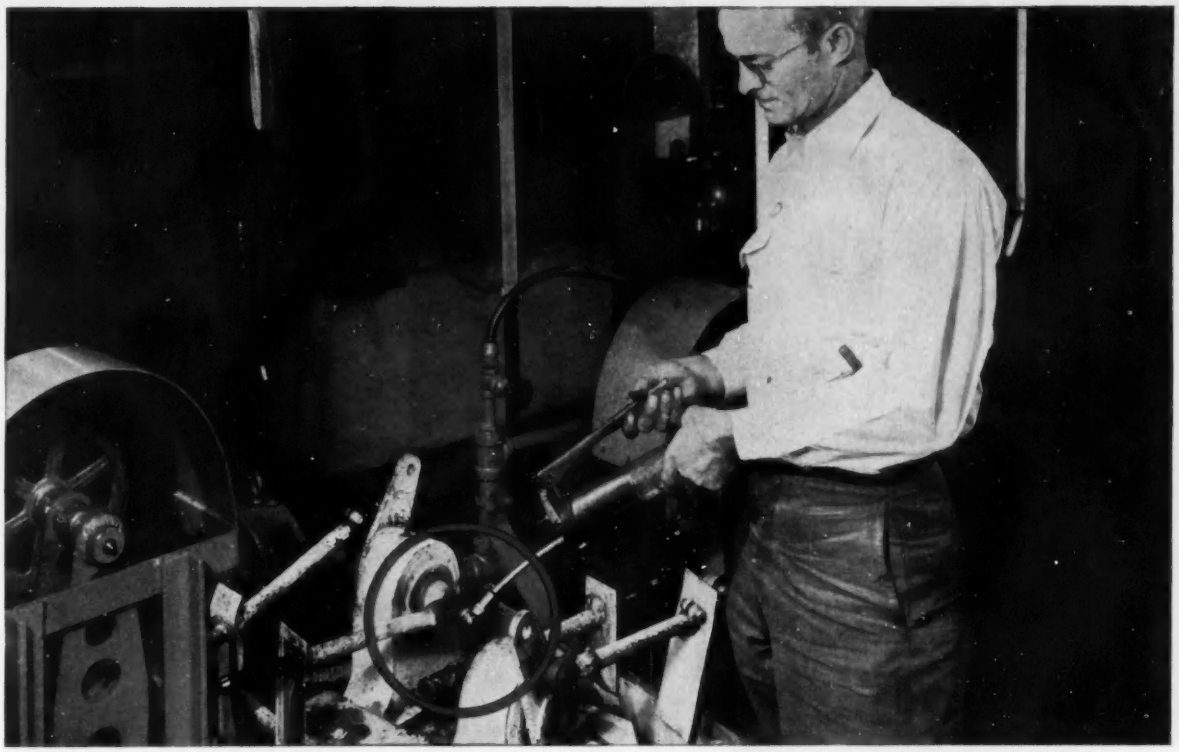
McCormick Bldg. • WAbash 2-6220

The Cleveland Graphite Bronze Company

DIVISION OF CLEVITE CORPORATION

You can count on

Thompson's Performance-Tested steering linkage



THIS "CAR" TRAVELS 1500 MILES A DAY!

IT'S not a *whole* car, of course. Just the important center link of a Thompson precision-made steering linkage. In the above picture, the center link is getting its daily... yes, *daily*...1500-mile lubrication!

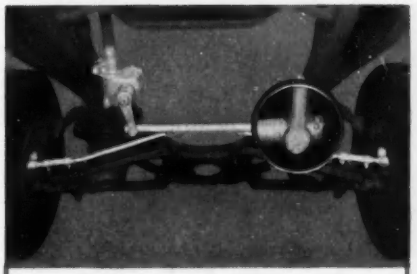
AROUND THE CLOCK—This is part of a grueling Performance Test that goes on in Thompson's Testing Laboratory 24 hours a day. Here the most extreme, difficult road conditions are duplicated. The Thompson steering link is subjected, hour after hour, day after day, to baths in mud and water . . . dry spells . . . jarring jolts of 300 pounds or more . . . and grinding, burning friction.

And, in addition, these rugged tests are supplemented by actual trial runs out on the road in standard-make cars.

WHY THESE TESTS? Because Thompson is continually striving for *improvement* . . . in materials, in performance, in manufacturing procedures. New materials, new processes, new designs are all subjected to these thorough Performance Tests . . . and always under the most extreme conditions.

THE RESULTS? These exacting tests in the laboratory and out on the open road . . . plus periodic skilled analyses by experienced Thompson engineers . . . result in the finest possible steering linkage for America's cars, trucks, buses and tractors.

If you have a steering linkage problem, let Thompson's steering engineers help you. Just write or phone Thompson Products, Inc., Michigan Plant, 7881 Conant Ave., Detroit 11, Mich., WA 1-5010.



You can count on

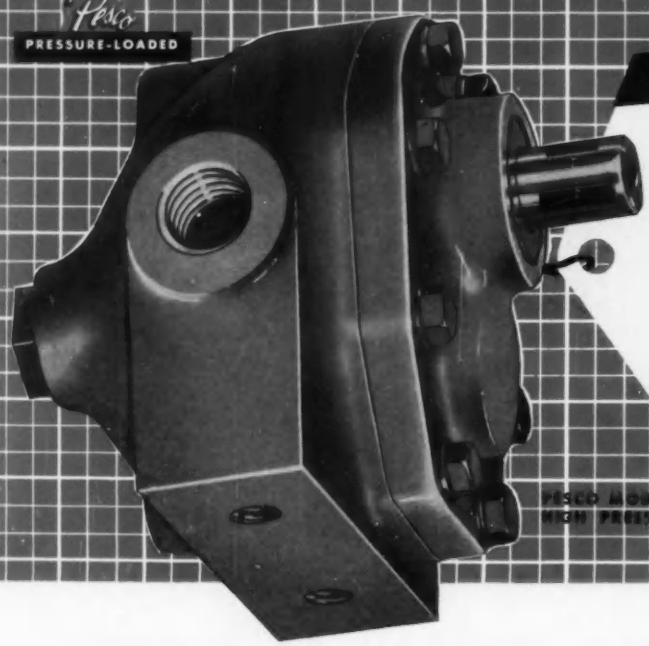
Thompson Products

MICHIGAN PLANT

Detroit • Fruitport • Portland

HERE'S A REALLY GREAT HYDRAULIC PUMP... it's PROVED and AVAILABLE!

Pesco
PRESSURE-LOADED



DEPENDABLE OPERATION • LOW MAINTENANCE

Pesco
HIGH PRESSURE GEAR PUMP

PRESSURES UP TO 2000 PSI

EFFICIENCIES: VOLUMETRIC—UP TO 94%
MECHANICAL—UP TO 88%

OPERATION: CONTINUOUS DUTY WITH OIL AT 150° F.

CAPACITY: 11 GPM AT 2400 RPM

AUTOMATIC ADJUSTMENT FOR OPERATING WEAR

PESCO MODEL 051002-110-01
HIGH PRESSURE GEAR PUMP

Here is a new Pesco *Pressure-Loaded* Pump you will want to investigate immediately! It is one of the most outstanding of many fine Pesco pump products, and provides unparalleled advantages for hydraulic power applications.

New developments of the famous Pesco Pressure-Loaded principle incorporated in this model have resulted in new high standards of performance and dependability. From the original development tests through many rugged field applications, this Pesco pump has constantly exceeded anticipated performance.

With volumetric efficiencies up to 94%, mechanical efficiencies up to 88%, and capacity of 11 gpm, it develops pressures up to 2000 psi. In addition, it operates on continuous duty with oil temperature of 150° F.

Pesco Hydraulic Engineers will be glad to show you how this outstanding Model 051002-110 will improve operation of your equipment. Simply call or write the Home Office, Bedford, Ohio.

Call or write the Home Office, Bedford, Ohio for full information on Hydraulic Pumps, Power Packages, Hydraulic Motors, Electric Motors, Controls and Valves.

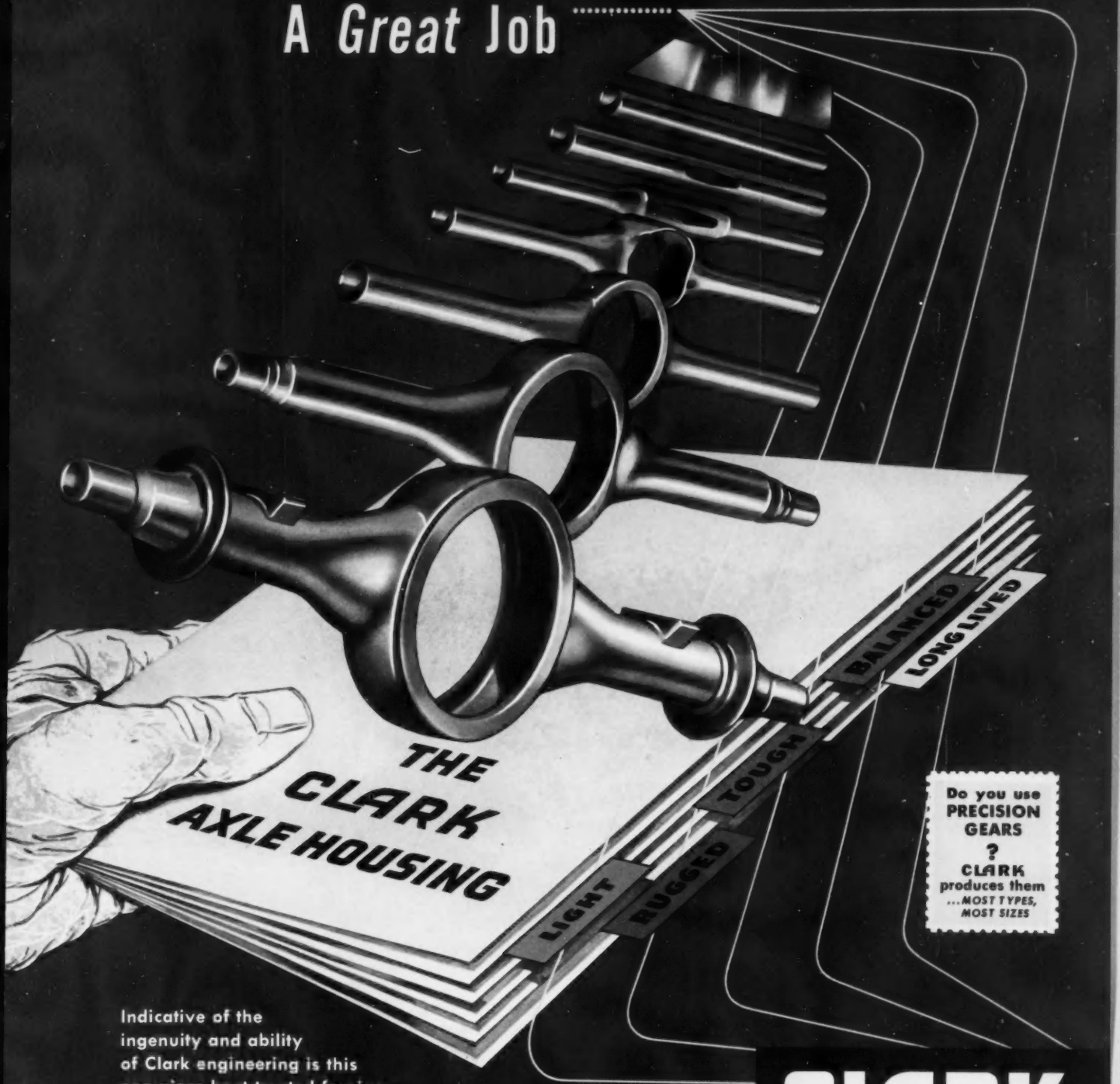
engineering Pesco production
PRODUCTS DIVISION

AGRICULTURAL INDUSTRIAL AIRCRAFT AUTOMOTIVE CONSTRUCTION EARTH MOVING

PRODUCING THE BEST IN HYDRAULIC EQUIPMENT AND ELECTRIC MOTORS

BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

A Great Job



Do you use PRECISION GEARS ? CLARK produces them ...MOST TYPES, MOST SIZES

Indicative of the ingenuity and ability of Clark engineering is this one-piece heat-treated forging— an axle housing that because of its design adds to the long life, dependability and owner satisfaction of any vehicle of which it is a part! Another reason why you'll find it's "good business" to do business with Clark.

CLARK* EQUIPMENT

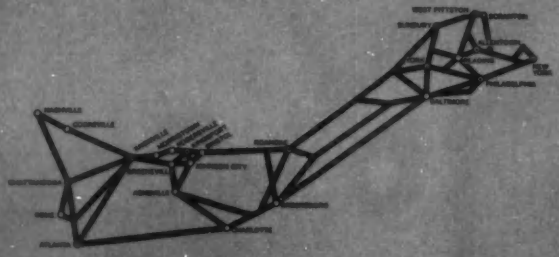
CLARK EQUIPMENT COMPANY, BUCHANAN, Battle Creek, Jackson, Benton Harbor, Michigan

Home terminal of the Mason and Dixon Lines, Inc.

From Atlanta to New York, Mason and Dixon Lines, Inc.

has standardized on Clark!

Here's why: "For 16 months, we conducted a proving ground for five leading makes of fork trucks at our Kingsport, Tenn., home terminal," says Mr. S. T. King, Executive Vice President, Mason and Dixon Lines, Inc. "After exhaustive tests on our docks, after closely checking maintenance records and interviewing our drivers, we standardized on Clarks as the most practical for our operations."



Mr. King adds another reason for their choice: no other fork truck manufacturer could meet the requirements of his company with the nation-wide *service* coverage of the Clark dealer organization. From Atlanta to New York, the Mason and Dixon Lines finds a Clark dealer close to every terminal. These Clark dealers provide maintenance coverage for Mason and Dixon's 29-truck fleet of Clarks, and training schools have been conducted at 6 major terminals for Mason and Dixon personnel.

Mr. King concludes: "Fork trucks permit us to *expedite* freight and give our customers better service. There's less damage to goods, our housekeeping and efficiency are better. We benefit, but the important thing is that our customers benefit from our fleet of Clarks"!

Mason and Dixon, one of the *nation's largest* independent truckers, selected Clark on the same basis they select over-the-road transportation—for all-round efficiency. Whether you have one terminal or many, there's a nearby Clark dealer to help you improve your handling efficiency. Call him today—he's listed in the Yellow Pages of your phone book.

CLARK EQUIPMENT

Industrial Truck Division
CLARK EQUIPMENT COMPANY
Battle Creek, Michigan

*TRADEMARK OF THE CLARK EQUIPMENT COMPANY

REDUCE WEIGHT of Jet Engine Plumbing up to 44%

Knife-like spur separates inner tube from wire braid during assembly.
Clamping action is exerted on reinforsing braid only.
Lip-seal is formed as end of hose inner tube seats in annular chamber.
"little gem" FITTING FEATURES

AEROQUIP 601 LIGHT-WEIGHT ENGINE HOSE

WITH DETACHABLE, REUSABLE *"little gem"* FITTINGS

● **UP TO 44% LIGHTER** than MIL-H-5511 . . . Aeroquip 601 engine hose features new thin-wall construction. Aeroquip ***"little gem"*** fittings provide additional weight savings.

● **UP TO 41% MORE FLEXIBLE** than MIL-H-5511 . . . Aeroquip 601 engine hose has a full cover stainless steel wire braid outer cover over a reinforced Buna-N inner tube. This allows tighter bend radius, reduces hose length, saves installation time.

● **UP TO 33% SMALLER O.D.** than MIL-H-5511 . . . Aeroquip 601 engine hose requires no cotton cover. Write for Bulletin AEB-3.

"little gem" is an Aeroquip trade mark

Aeroquip

REG. TRADE MARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN
AERO-COUPLING CORPORATION, BURBANK, CALIFORNIA
(A Subsidiary of Aeroquip Corporation)

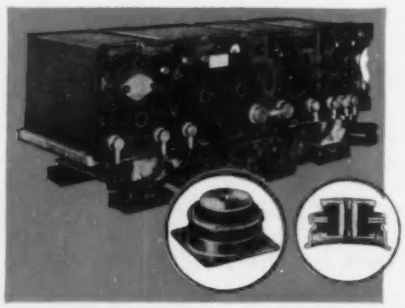
Manufacturers of Aeroquip Flexible Hose Lines with detachable, reusable Fittings; Self-Sealing Couplings; Brazed Aluminum Elbows
LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD ● AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

JUST A MATTER OF CONTROL

LORD ENGINEERING CONTROLS VIBRATION ... anywhere!

Your continuing effort to improve your products and reduce their maintenance cost may be entirely A Matter Of Control . . . the control of destructive vibration and shock. To help you to accomplish your objectives, Lord Engineering recommends the correct design, selects the most suitable elastomer and metal, and uses precision manufacturing for all Vibration Control Mountings and Bonded Rubber Parts. Your vibration and shock control problems are our business. We welcome the opportunity of placing our wide experience in many diversified industries at your disposal.

Over 27,000 designs and their variations from which to choose.



The sensitivity of many commercial and military radio transmitters is protected . . . their accuracy is insured against vibration and shock damage by Lord Vibration Control Mountings. Ask for complete details.

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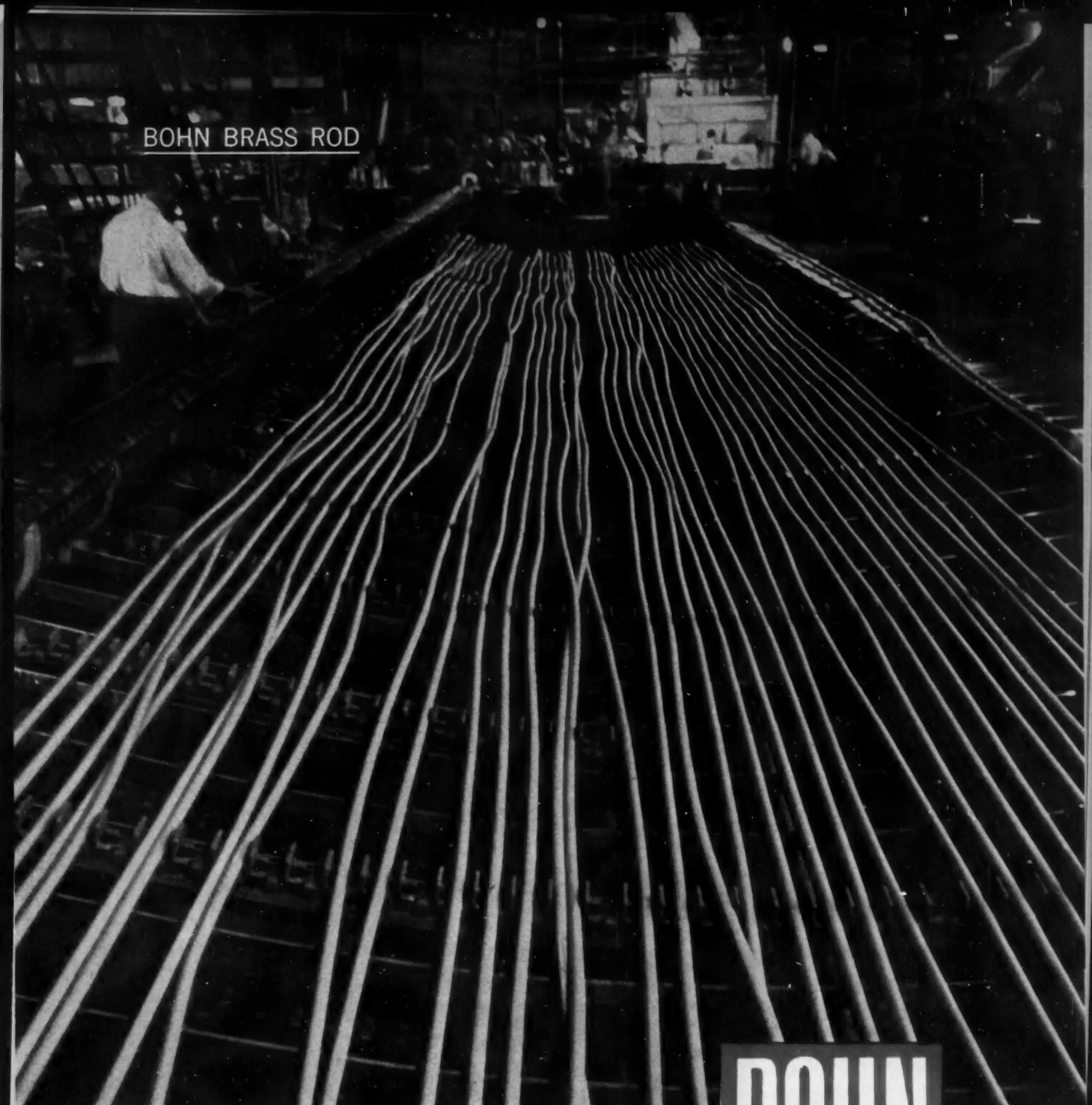
DETROIT 2, MICHIGAN, 311 Curtis Building — NEW YORK 16, NEW YORK, 280 Madison Avenue — CHICAGO 11, ILLINOIS, 520 N. Michigan Ave. — CLEVELAND 15, OHIO, 811 Hanna Building

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER — *Headquarters for* VIBRATION CONTROL FOR 30 YEARS



BRASS ROD IS COOLED ON CONVEYOR RACKS WHICH CARRY IT TO FINISHING OPERATIONS, STRAIGHTENING

control your temper Bohn brass rod, temper-tailored for your job, can help you reduce machining costs. Equally important, Bohn's rigid controls—from billet to final inspection—assure you even temper every shipment. Close control of tailored tempers is one more reason America's leading manufacturers specify brass rod by Bohn.

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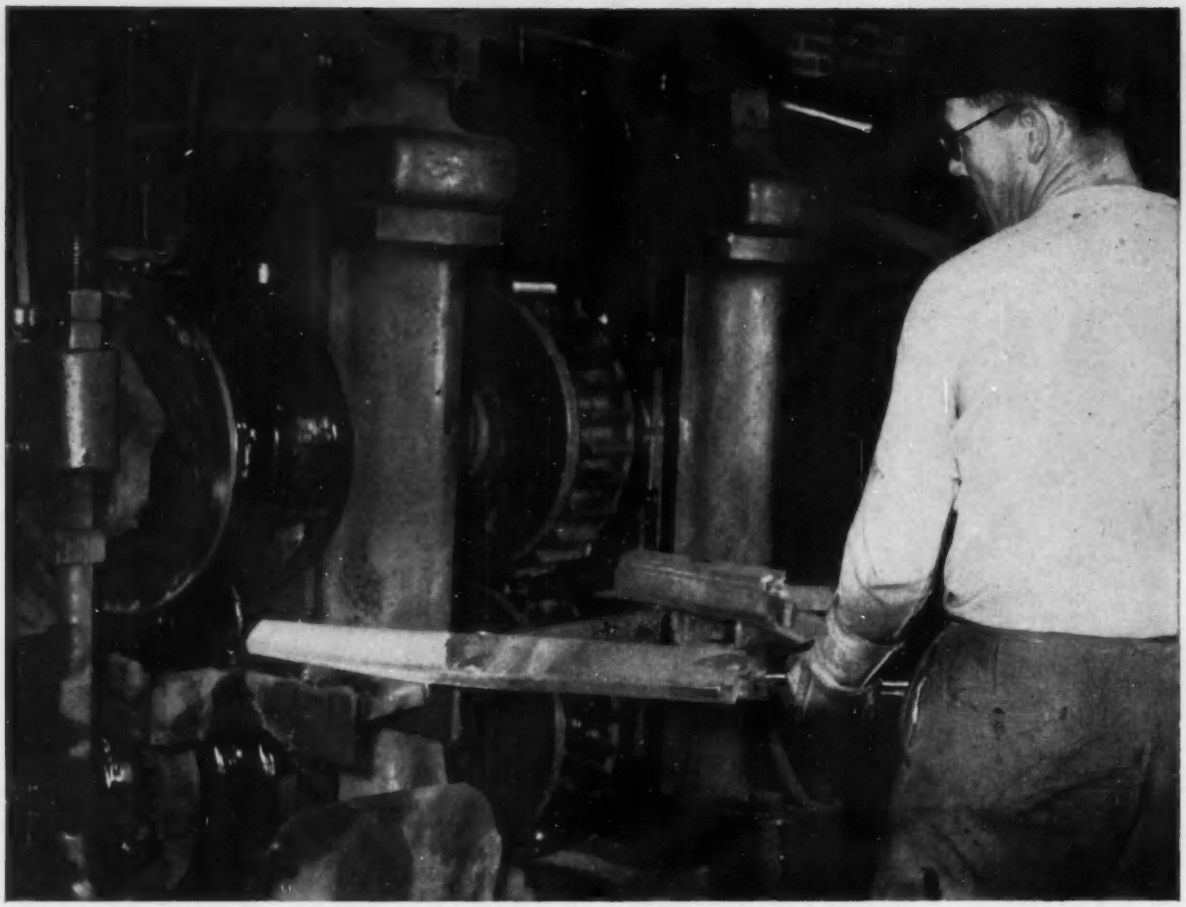
1400 LAFAYETTE BLDG.
DETROIT 26, MICHIGAN

NEW BOOKLET
"Bohn Products and How They are Made."
Write for free copy of this pictorial tour through Bohn plants.



10 TIMES THE PRODUCTION LIFE

FROM THESE "CAST-TO-SHAPE" SWAGING DIES

SEND FOR THIS NEW CATALOG
"FORGING AND CASTING PRODUCTS"

It's hot off the press with full details on FCC Air Hardening, Oil Hardening and other Cast-to-Shape Tool Steel Specialties that can save you time and money . . . also Composite Die Sections, and Smooth-Hammered Forgings in a wide range of tool and stainless steels. *Don't wait—get your copy NOW.*

Write Today
ADDRESS DEPT. SA-57

The John Deere Plow Works of Deere & Company formerly used cast grey-iron dies to swage AISI 1070 F steel plow beams. Die life was, at best, a mere six weeks or about 8,000 parts.

They switched to A-L CAST-TO-SHAPE swaging dies of FCC No. 66 tool steel, hardened and drawn to 57-58 Rockwell "C". The new dies ran *fourteen months*—eight hours a day, five days a week—before redressing was necessary. Approximately *83,875 Parts* (over ten times the production) were swaged in that period! Production has been maintained at that level since.

You, too, can save time and money with the modern FCC CAST-TO-SHAPE method of tool and die making. Don't forget, you also buy *less* steel and reduce machining costs. It's a matter worth investigating. ● Check with your A-L representative TODAY . . . or write *Allegheny Ludlum Steel Corporation, Oliver Building Pittsburgh 22, Pennsylvania.*

For complete MODERN Tooling, call
Allegheny Ludlum

AL
FINE TOOL STEELS
SINCE 1854

W&D 4681

Toughest jobs on wheels . . . are jobs for Kelsey-Hayes

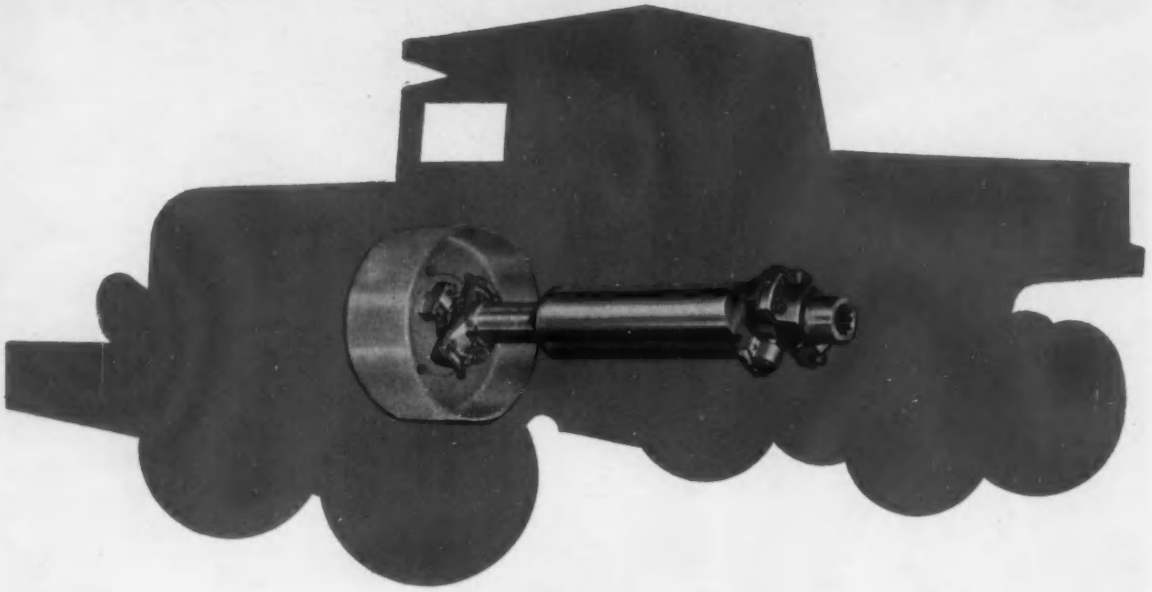
Keeping heavy loads on the move where the going gets tough is routine rolling for Kelsey-Hayes Wheels. They're built to take it. They're engineered for brutal punishment with an extra measure of strength and stamina for steady, trouble-free rolling on the job, any job, anywhere. And the makers of motor vehicles know this. For today, as in the past 45 years, they rely on Kelsey-Hayes for wheels of rugged dependability—wheels for trucks, trailers, tractors, buses and passenger cars.
Kelsey-Hayes Wheel Co., Detroit 32, Mich.

KELSEY HAYES

World's Largest Producer of Automotive Wheels

Wheels, Brakes, Hubs, Brake Drums, Special Parts for all Industry • 9 Plants—Detroit and Jackson, Mich. . . . McKeesport, Pa. . . . Los Angeles . . . Windsor, Ont., Canada . . . Davenport, Ia. (French & Hecht Farm Implement and Wheel Div).

RUGGED

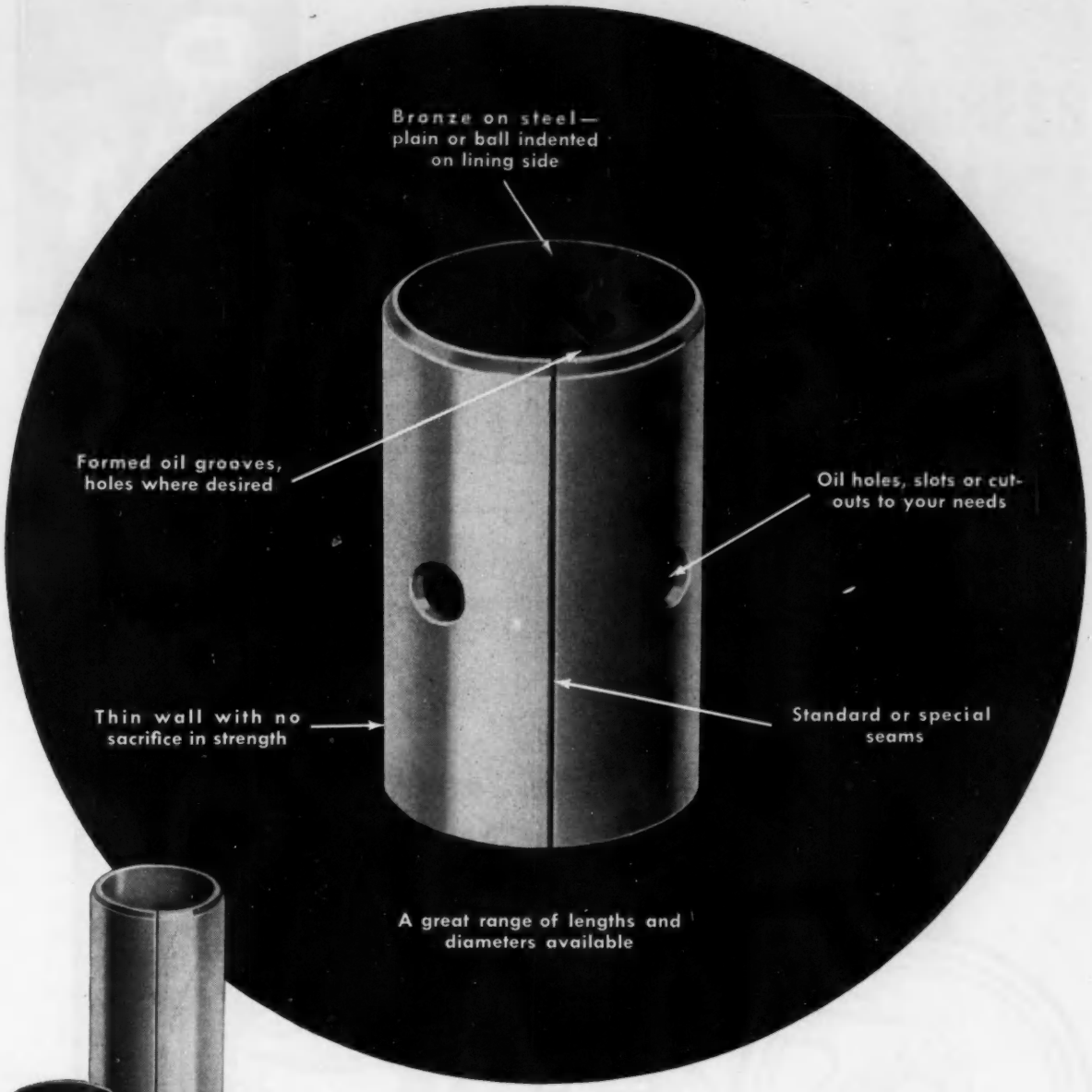


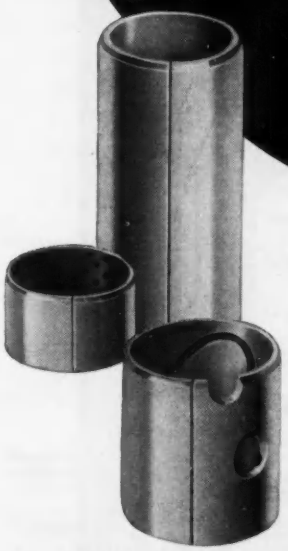
Because MECHANICS Roller Bearing UNIVERSAL JOINTS drive through KEYS—instead of bolts—they stand up under punishment that shears off other types of fasteners. They are designed with less parts and connections for easy assembly and servicing — smooth running balance — maximum strength with less weight — and long, trouble-free, safe operation. Rugged stamina is just one of the advantages you get when you specify MECHANICS Roller Bearing UNIVERSAL JOINTS. Let MECHANICS engineers help you design this and other competitive sales features into your product's transmission train.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2022 Harrison Ave., Rockford, Ill.

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment





Also available in tin-base or lead-base babbitt on steel.

Get bearing performance at bushing cost. Save material, time and labor with Federal-Mogul bimetal rolled split bushings. Quality production in large volume runs for hundreds of uses can mean savings in *your* application.

FEDERAL-MOGUL CORPORATION, 11035 Shoemaker, DETROIT 13, MICHIGAN

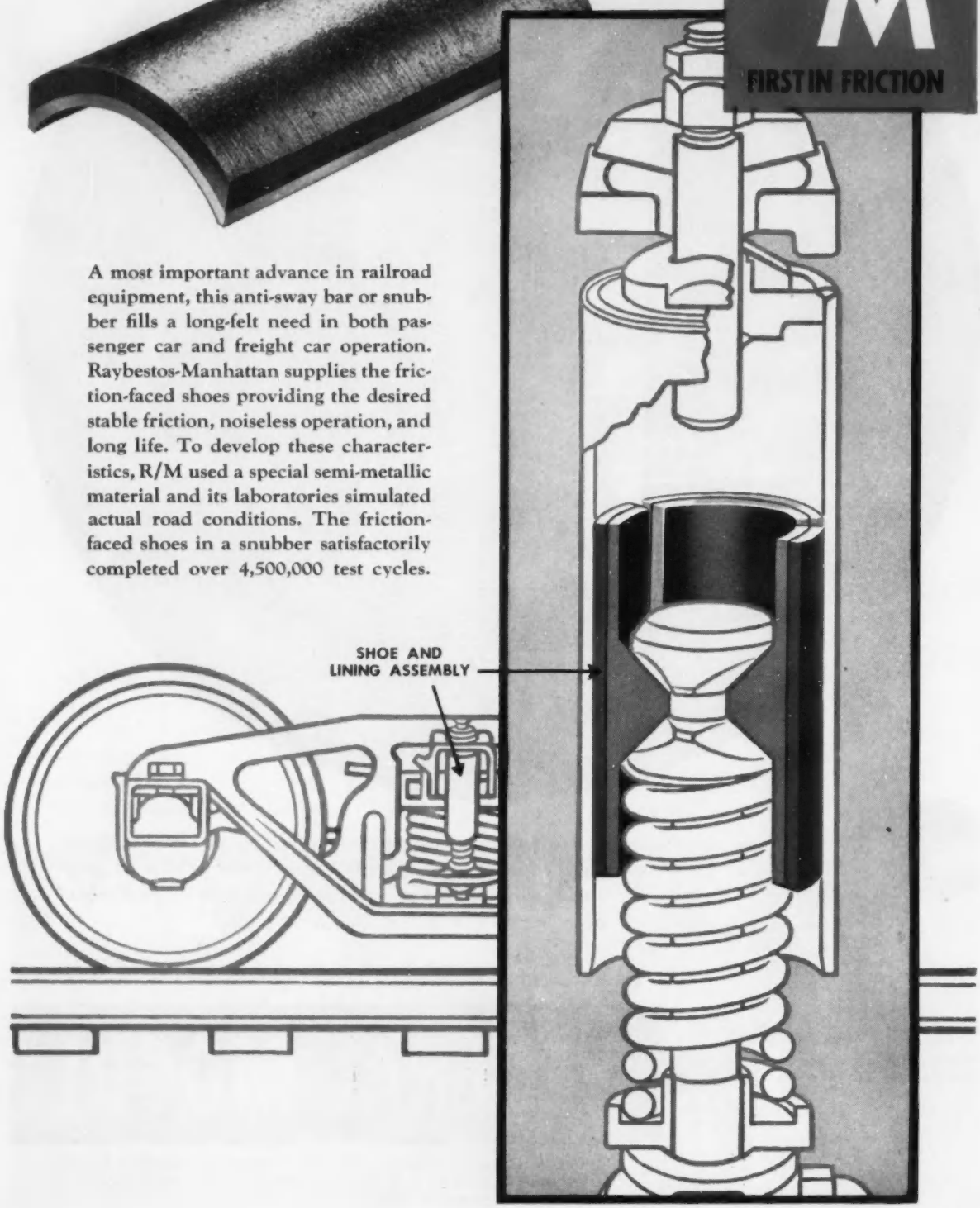
FEDERAL-MOGUL

since 1899

Sleeve bearings in all designs and sizes; cast bronze bushings; bimetal rolled bushings; rolled split bushings; washers, spacer tubes, precision bronze parts and bronze bars.

R/M
FIRST IN FRICTION

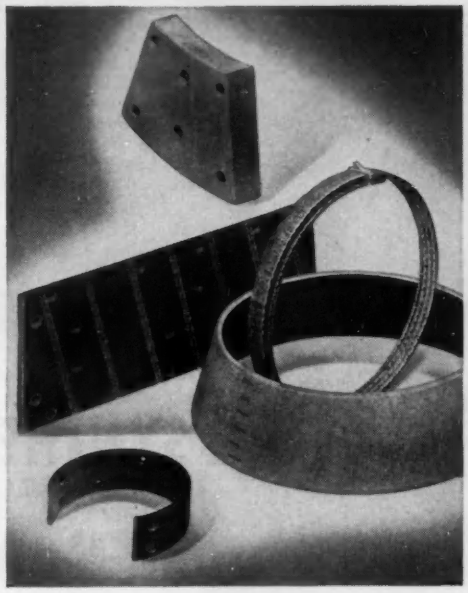
A most important advance in railroad equipment, this anti-sway bar or snubber fills a long-felt need in both passenger car and freight car operation. Raybestos-Manhattan supplies the friction-faced shoes providing the desired stable friction, noiseless operation, and long life. To develop these characteristics, R/M used a special semi-metallic material and its laboratories simulated actual road conditions. The friction-faced shoes in a snubber satisfactorily completed over 4,500,000 test cycles.



THE TRADE-MARK THAT SPELLS PROGRESS IN FRICTION MATERIAL DEVELOPMENT!

If you have a problem in design or manufacture that involves friction materials, talk to Raybestos-Manhattan, world's largest maker of friction materials. Working in both the asbestos and the metal fields, R/M is in the right position to give you impartial advice.

R/M's extensive experience with woven and molded asbestos, semi-metallic materials, and sintered metals has proved invaluable to countless manufacturers in all kinds of industries. So your problem could very well be one that R/M has already studied and solved. In any case, get to know your R/M representative. Call him in and take advantage of R/M's vast research production facilities.



R/M's complete line of friction materials includes woven and molded asbestos parts in the form of blocks, segments, discs, cones, collars, and many special shapes.

Write for your copy of the R/M Engineering Bulletin. It describes and illustrates many R/M friction materials for aviation, agriculture, the automobile industry and others

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION 6010 Northwest Highway, Chicago 31, Ill.

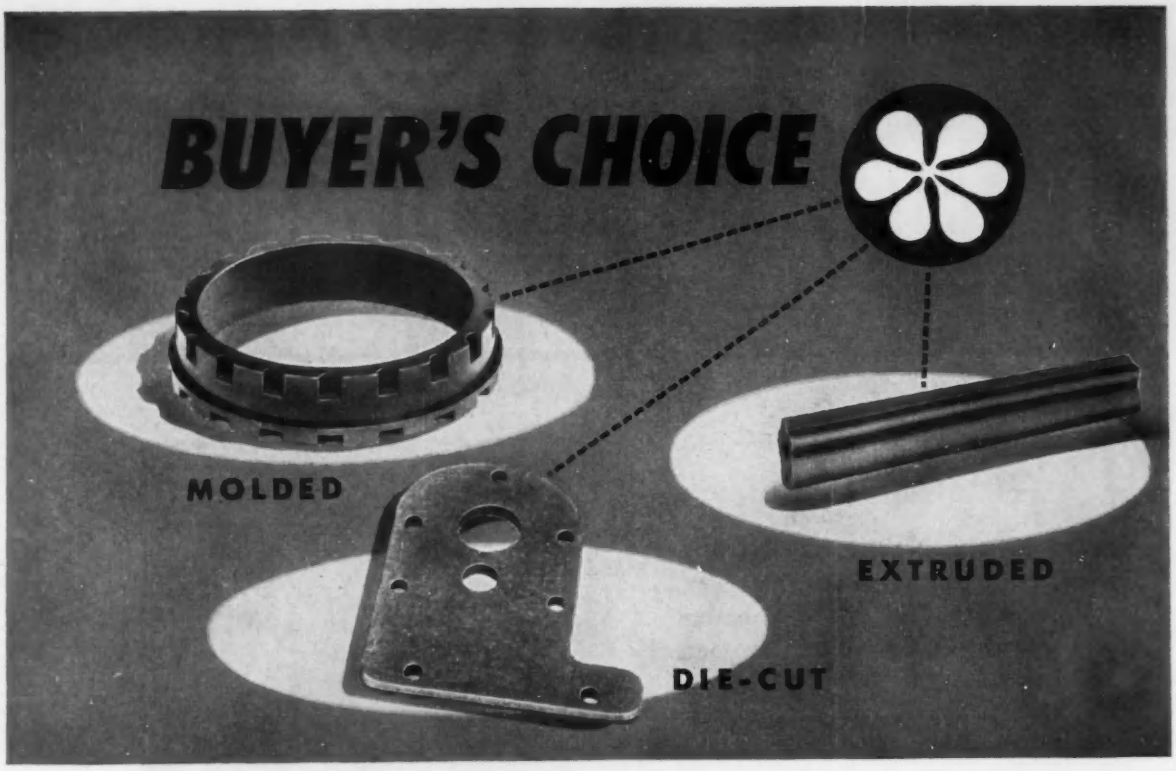
Detroit 2 Cleveland 14 Los Angeles 58

Factories: **Bridgeport, Conn. Manheim, Pa. Passaic, N.J. No. Charleston, S.C. Crawfordsville, Ind. Neenah, Wis. Canadian Raybestos Co. Ltd., Peterborough, Ont.**

RAYBESTOS-MANHATTAN, INC. Brake Linings • Brake Blocks • Clutch Facings • Fan Belts Radiator Hose • Industrial Rubber, Engineered Plastic, and Sintered Metal Products • Rubber Covered Equipment • Asbestos Textiles • Packings • Abrasive and Diamond Wheels • Bowling Balls

R M

FIRST IN FRICTION



*ACADIA SYNTHETIC RUBBER PARTS ARE MADE ALL 3 WAYS!

With Acadia you have a *choice!* Not only molded rubber . . . not only molded and die-cut . . . not only extruded rubber . . . but rubber parts any way you require! Better yet, Acadia uses whatever method the requirements of the job and you dictate is the *best* way to do it.

Acadia is especially sensitive to your specifications. We will process synthetic components for oil-resistance—good aging properties—resistance to heat—any characteristic you're seeking, or a combination of characteristics. Acadia parts are cut, molded or extruded to all required shapes, sizes and types, with almost unlimited applications.

Also, we offer Acadia SILICONE Rubber, molded or extruded for gaskets, seals, "O" rings, washers, sheets, cut-parts and packings. This is the rubber that will stay resilient at 100° *below* zero, or 500° above!

There's an Acadia Sales Engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

ACADIA Synthetic PRODUCTS

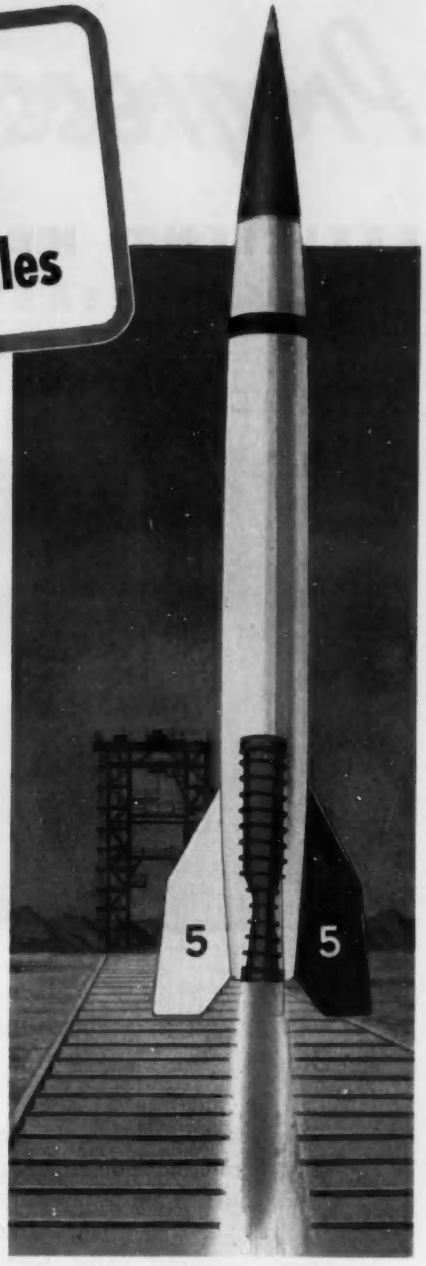
DIVISION OF WESTERN FELT WORKS

4021-4139 W. Ogden Ave., Chicago 23, Illinois

Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT

RYAN builds ROCKET MOTORS for 3000 mile-per-hour missiles



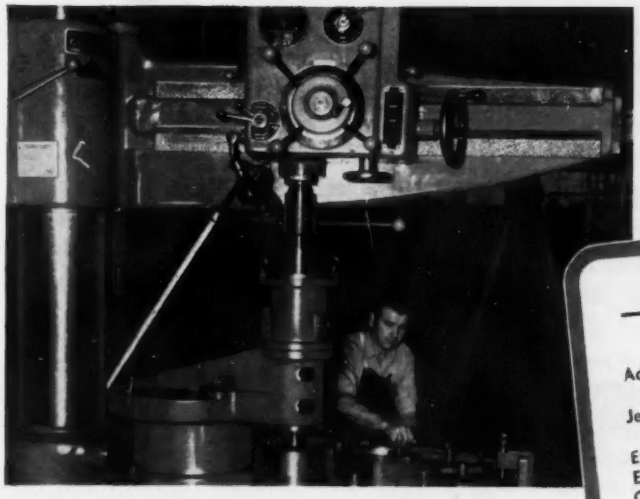
IMAGINE a motor powerful enough to propel a missile at speeds exceeding 3000 mph . . . so powerful that its developed thrust can amount to tens of thousands of pounds. One of Ryan's most challenging current assignments is the complete production of such a motor for an Army Ordnance surface-to-surface missile.

There was a many-sided problem of fabrication, welding and machining that Ryan had to solve in connection with rocket motor manufacture. Because a rocket motor is capable of burning as much as a ton of fuel a minute at temperatures up to 5000 degrees F., terrific internal pressures are created that must be contained in a very compact package of complex construction and exacting dimensions.

The solution was found in perfecting new techniques for forming, welding and machining the special alloy materials. Ryan devised new methods of controlling work to very close tolerances; ingenious electric resistance and arc welding processes and a better furnace brazing system . . . plus intricate machine operations that had to be jewel-like in precision.

Ryan's proved ability in the production of complete rocket motors is due in large measure to its long experience in building the "hot end" of jet and piston engines. Its versatility in many specialized fields is an important advantage in each new assignment, for it enables every division to draw on 31 years of first hand experience in the most advanced phases of aviation engineering and production.

Thus, each year more unique technical engineering and production projects are awarded Ryan . . . an integrated company with superior abilities in meeting the challenges of today's high-speed air age.



RYAN AERONAUTICAL COMPANY

Factory and Home Offices: Lindbergh Field, San Diego 12, California

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RYAN SPECIALIZED INGENIOUS VERSATILE

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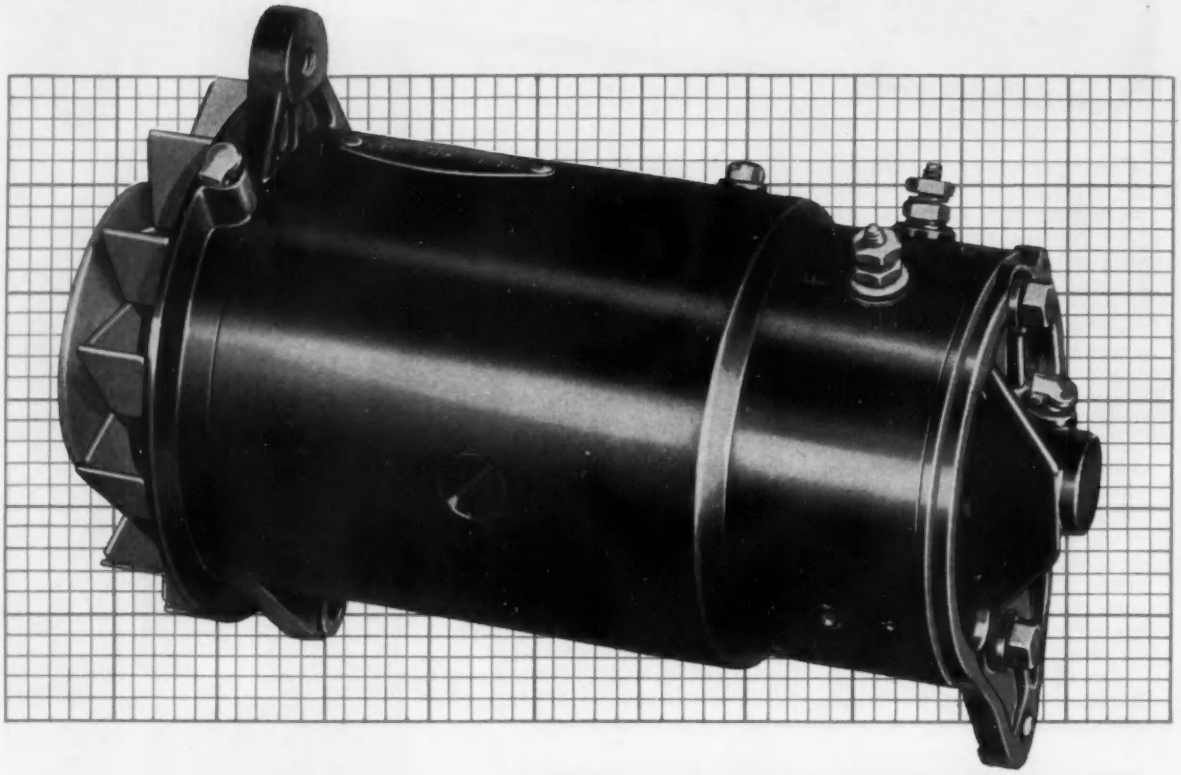
PIONEERS IN EACH ★ LEADERS IN ALL

Progressive Engineering

EFFICIENT NEW DELCO-REMY 12-VOLT



When today's stepped-up engines called for faster cranking and better ignition performance, Delco-Remy was ready, with a complete 12-volt electrical system, comprising new, balanced units—battery, cranking motor, generator, coil and distributor.

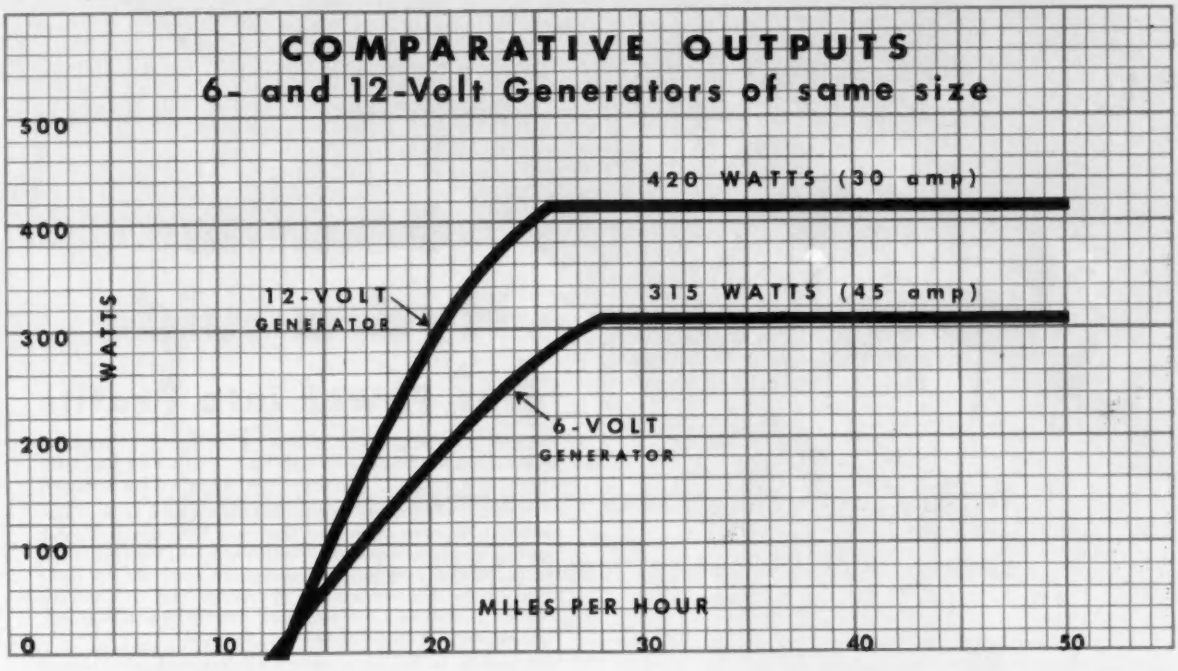
Delco-Remy's new 12-volt generator is identical in size and appearance with the previous 6-volt generator—but packed inside is the ability to produce at least 30 per cent *more output*. This designed-in ability permits the new 12-volt generator to supply the need for more electrical energy for radio, heater, additional lights, transmission control, electric windshield wipers, window and seat controls and the multitude of other units requiring electrical power to operate them—as well as to keep the battery properly charged for faster cranking and better ignition performance at every engine speed. Note, too, that the new generator delivers more output at lower car speeds—an important battery-saving bonus feature when prolonged slow driving is necessary.

The basic technical reasons for this remarkable performance may be stated simply—

AUTOMOTIVE, TRACTOR AND MARINE ELECTRICAL EQUIPMENT

Makes the Difference

GENERATOR FOR PASSENGER CARS DELIVERS UP TO 30% GREATER OUTPUT



stronger fields, less field distortion from armature reaction, and a lower percentage of internal voltage drop. These important gains are made possible by the use of new field coils containing more turns of smaller wire and a new armature with 60% more conductors in smaller slots, giving more tooth area.

This generator for passenger car 12-volt electrical systems is only one example of how Delco-Remy's Progressive Engineering keeps always abreast—usually ahead—of developments in the automotive industry. When the need arises for even more advanced automotive equipment, you know that Delco-Remy will be ready.

Delco-Remy

DIVISION, GENERAL MOTORS CORPORATION, ANDERSON, INDIANA

AUTOMOTIVE, TRACTOR AND MARINE ELECTRICAL EQUIPMENT

WHEREVER YOU TURN
WHATEVER YOU STEER
Gemmer
Hydraguide
turns Power into Profits
Vehicles weighing 1 ton, 5 tons or 20 tons . . . tractors, graders, trucks, boats, automobiles . . . whatever you turn, wherever you turn . . . Gemmer Hydraguide turns it better!
A powerful statement? Yes, but being a fact, it is of tremendous importance to you. Gemmer Hydraguide Power Steering does more than 80% of the work of steering. Even in the heaviest equipment, Hydraguide gives the operator finger-tip control without loss of driving "feel" . . . reduces fatigue . . . insures a more efficient money-time saving job. Put Gemmer Hydraguide to work for you!
Hydraguide is the pace-setting achievement of Gemmer Manufacturing Company . . . since 1907 makers of the finest in manual and power steering units.
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genuine Leather

gives a better buy to buyers ...a bigger profit to you

● One of the best sales features a car can have —in *any* price class—is upholstery of genuine leather. No other material adds so much extra value to a car for so little . . . or offers so much added profit for you.

Genuine upholstery leather costs little more than good seat covers . . . takes hard wear in stride and actually *improves* with age. It's the ideal car upholstery because it is always easy to "slide" on, resists hot sunlight and bad weather, holds its color and beauty for years without fading. Leather is always comfortable —becomes softer and more pliant with age— develops a rich patina that distinguishes it from any substitute. And genuine upholstery leather means a higher trade-in value. Sales reports show that it increases the resale value of any car. Nothing adds luxury, value and profit to a car like leather. Why sell less?

SEND FOR THIS FREE BOOKLET

"All About Genuine Upholstery Leather," the new, free fact-booklet on leather is yours for the asking. It contains some interesting reasons why genuine upholstery leather is the best buy for your customers—best buy for you. Write for it today. There's no obligation.

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"it is significant..."

THE FOUR WHEEL DRIVE AUTO
MFRS. OF FWD TRUCKS
CLINTONVILLE, WIS.

OFFICE OF THE PRESIDENT

January 19, 1954

Blood Brothers Machine Division
Rockwell Spring & Axle Company
Allegan, Michigan

Gentlemen:

In November, 1953, The Four Wheel Drive Auto Company introduced a new line of four and six wheel drive trucks to mark the Company's 43rd year in the heavy duty truck field.

I think it is significant that Blood Brothers has supplied us with propeller shafts and alignment joints every one of those 43 years. From the first FWD Model B trucks built in 1910, to the latest 1954 models now on our production line, Blood Brothers drive lines have been used and are now being used as standard equipment.

To me that is an honest measure of our faith in your product. In our experience, Blood Brothers has always meant a fine product backed by excellent service and cooperation. I am sure that the same can lead to many more years of business ...een your Company and FWD.

Yours very truly,

Robert A. Olen

Robert A. Olen
President and General Manager

BB DIV.

UNIVERSAL JOINTS
AND DRIVE LINE ASSEMBLIES

BLOOD BROTHERS machine division
Rockwell Spring and Axle Company
ALLEGAN, MICHIGAN

Superior

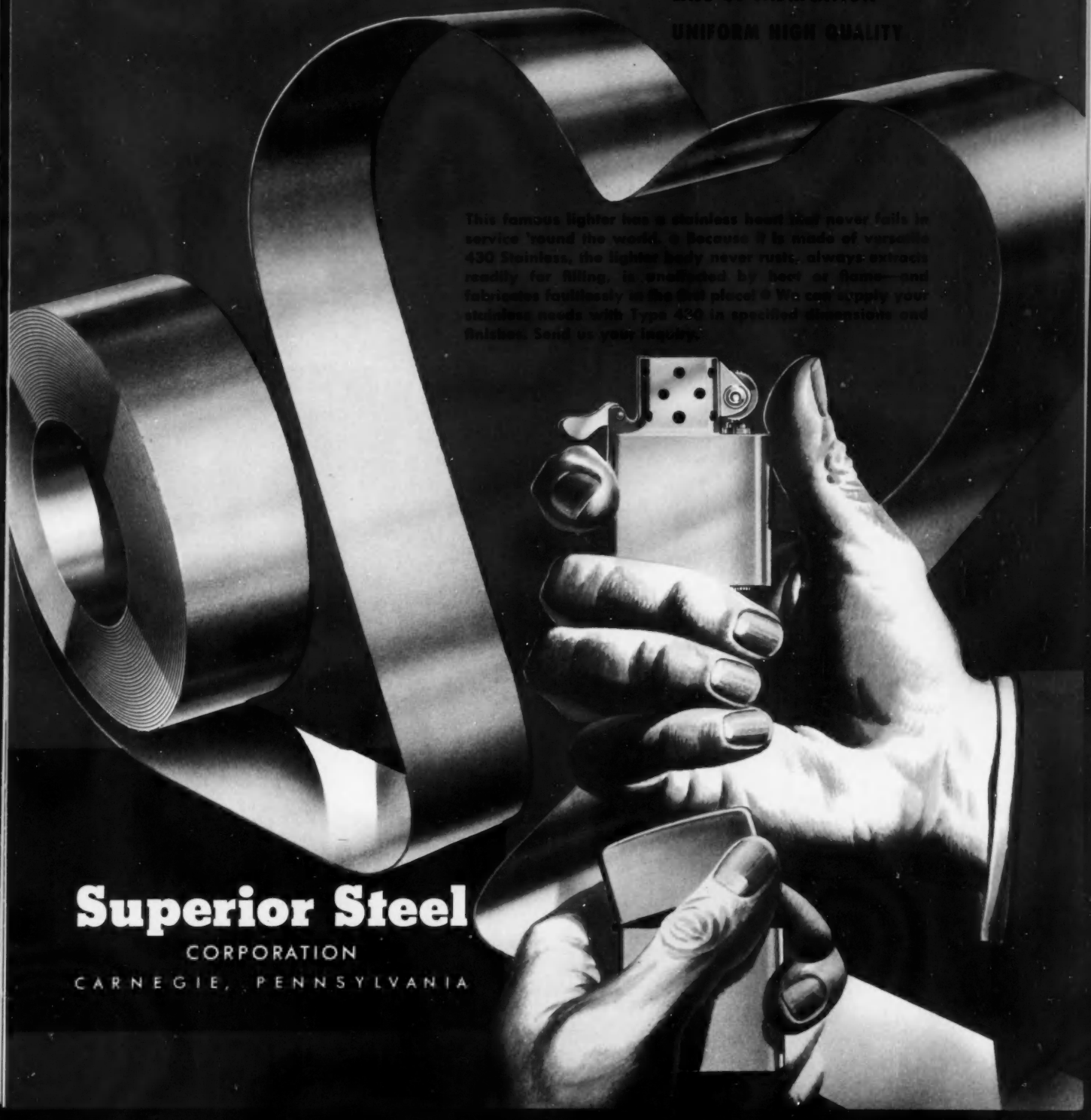
TYPE 430

STAINLESS STEEL

FOR HEAT RESISTANCE
RESISTANCE TO CORROSION
EASE OF FABRICATION
UNIFORM HIGH QUALITY

The Heart of the Lighter

This famous lighter has a stainless heart that never fails in service 'round the world. ◇ Because it is made of versatile 430 Stainless, the lighter body never rusts, always extracts readily for filling, is unaffected by heat or flame—and fabricates faultlessly in the first place! ◇ We can supply your stainless needs with Type 430 in specified dimensions and finishes. Send us your inquiry.



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CORPORATION
CARNEGIE, PENNSYLVANIA

Private "air truck" for Very Special Delivery

...powered by Lycoming

When deliveries are *Rush* with a capital "R" . . . today's progressive businessman turns to a small company plane that relieves him of dependence on the schedules of commercial air-freight systems.

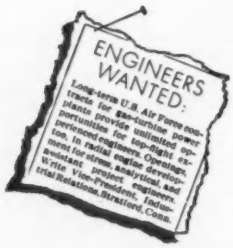
Take the case of the Capital City Printing Plate Company of Des Moines, Iowa . . . operator of a Piper Tri-Pacer powered by Lycoming. Gene C. Meston, General Manager, says: "We could not maintain our production and sales level without the Tri-Pacer. The airplane and the pilot do the work of two trucks and three drivers. We save a lot of expense and keep our customers well satisfied."

Our own experience at Lycoming with the Tri-Pacer is a revelation in dollars and cents. It carries a 500-lb. payload at an operating cost of only 5.6¢ per mile . . . *less than the average cost of running an automobile!*

For the "air truck" in *your* future, test-fly a Piper . . . or one of the other leaders in this small-plane field that fly with dependable Lycoming air-cooled engines.

Off again to deliver the goods! Tom Vodenik, Capital City pilot, shown here, says: "We logged over 750 hours in the first eight months we flew this Tri-Pacer. The plane has had nothing but routine maintenance—it's ready to go every day!"

Just off the press! "The Lycoming Story" . . . 40 interesting, illustrated pages showing many ways Lycoming is ready to help you. Write for it on your letterhead.



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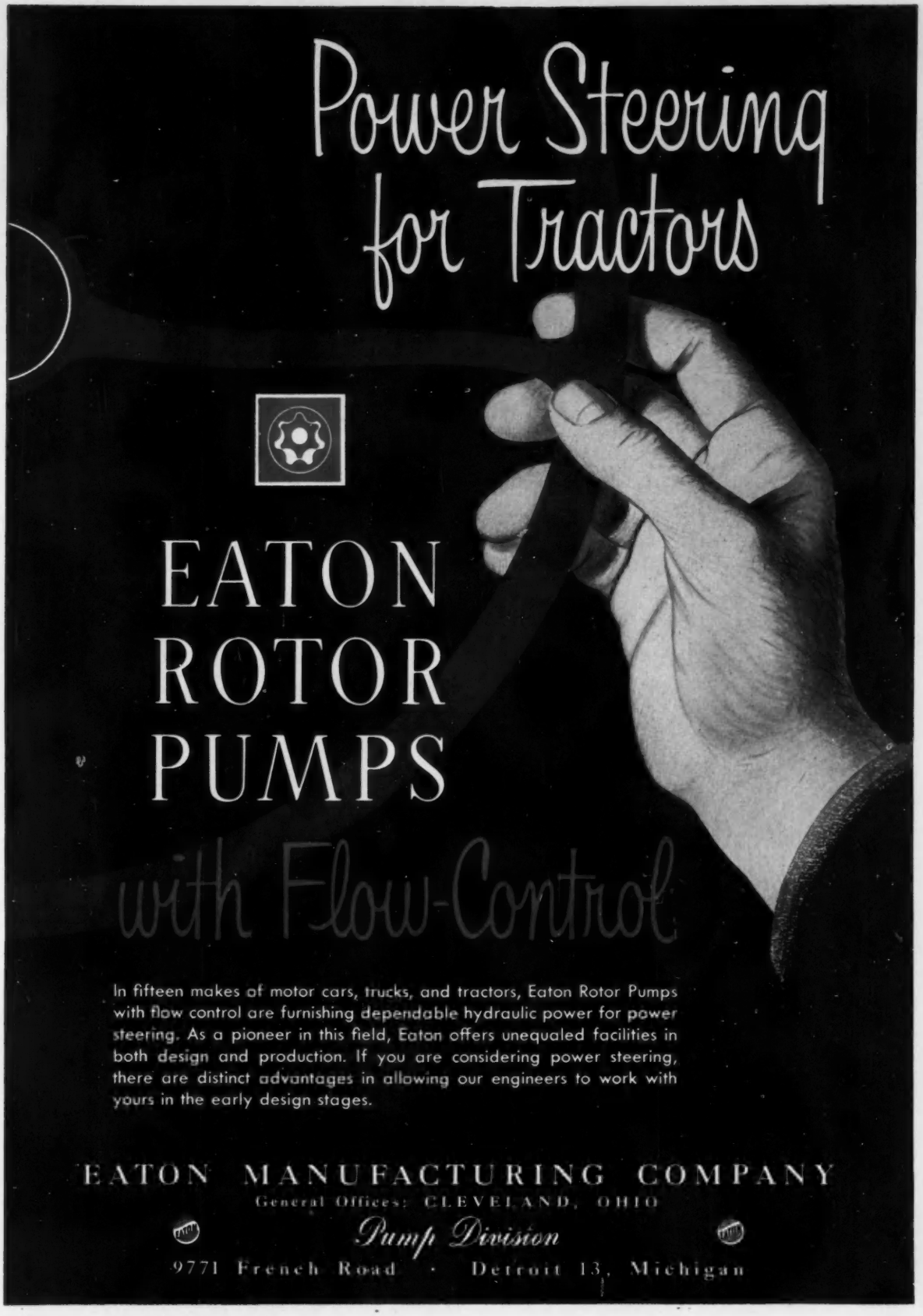
Manufacturing plants in Stratford, Conn., and Williamsport, Pa.

Power Steering for Tractors



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with Flow-Control

In fifteen makes of motor cars, trucks, and tractors, Eaton Rotor Pumps with flow control are furnishing dependable hydraulic power for power steering. As a pioneer in this field, Eaton offers unequaled facilities in both design and production. If you are considering power steering, there are distinct advantages in allowing our engineers to work with yours in the early design stages.

EATON MANUFACTURING COMPANY

General Offices: CLEVELAND, OHIO

Pump Division

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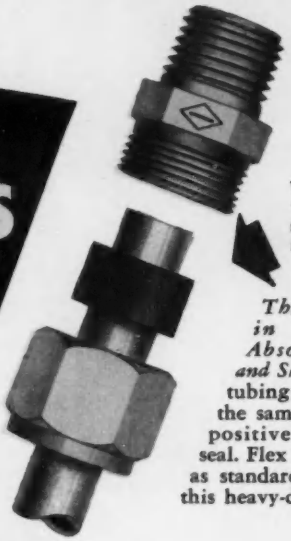
Got a tough tubing connection job?...

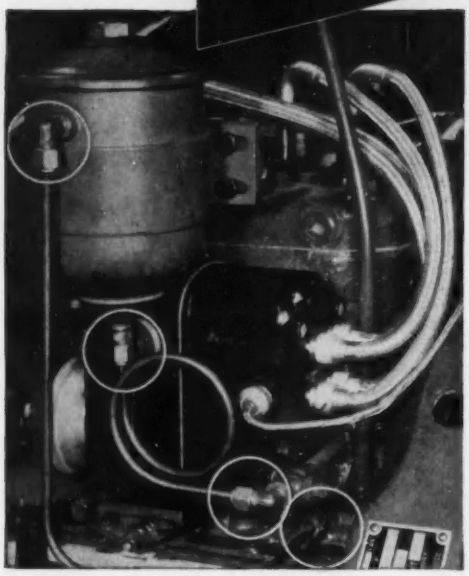
IMPERIAL FLEX FITTINGS

May Be the Answer

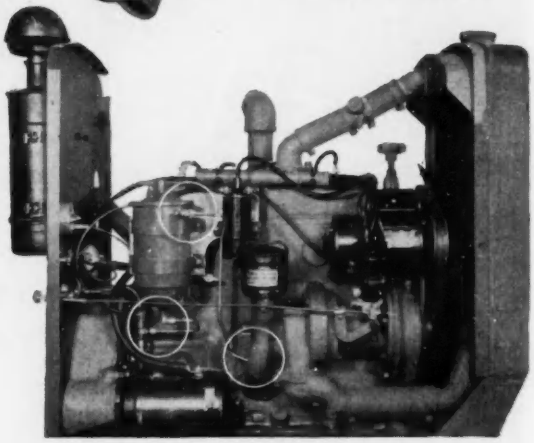


The tube coupling with vibration and shock absorbing sleeve.

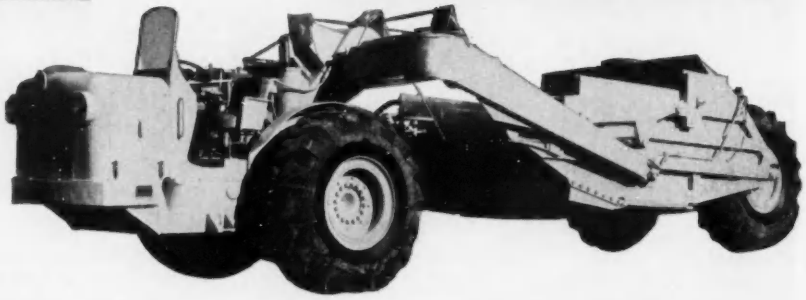
This Elastic Sleeve in Flex Fittings Absorbs Vibration and Shock . . . permits tubing to flex and at the same time assures a positive pressure tight seal. Flex Fittings are used as standard equipment on this heavy-duty engine.



Flex Fittings make joints virtually indestructible by VIBRATION . . . withstand SHOCK and MINOR TUBE MOVEMENT



Flex Fittings, circled on this engine, are very easy to install . . . simply slip nut and Flex sleeve over tubing . . . insert tubing into body as far as it will go and tighten nut—that's all.



Whether it's earth movers (illustrated), tractors, diesel engines, heavy power equipment or machinery, Flex Fittings will do the job. They have been thoroughly proved by extensive use.

Flex Fittings Can Be Used With All Kinds of Tubing

Imperial Catalog 344 gives you complete information on Flex Fittings. Ask for your copy.

THE IMPERIAL BRASS MFG. CO., 1225 W. Harrison St., Chicago 7, Illinois

IMPERIAL

PIONEERS IN TUBE FITTINGS AND TUBE WORKING TOOLS

One source

FOR YOUR CASTING REQUIREMENTS

one book

WILL GIVE YOU THE WHOLE STORY

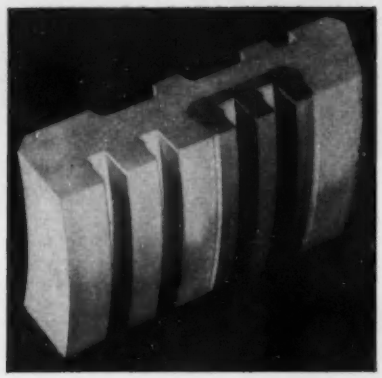
CWC

WRITE FOR IT TODAY!

Here is a 24-page booklet that contains the most up-to-date information on gray iron and steel castings: intricate, general purpose, those with special properties, heat-treated and centrifugal. Called "One Source," it's a booklet you'll want to read and keep as an important casting reference. It explains just what one-source supply by Campbell, Wyant and Cannon can mean to you, how it assures you of better, lower-cost castings . . . no matter what your quantity requirements. It tells, too, how CWC one-source responsibility works for you in terms of thorough and continued service . . . fast, dependable delivery. Of course there's more to the "One Source" story, *much* more. Write for your copy now!

CAMPBELL, WYANT AND CANNON
FOUNDRY COMPANY
Muskegon, Michigan

A Ni-Resist Ring Band is an integral part of this forged aluminum piston for Nordberg 11- and 12-cylinder Radial engines. Sectional view indicates the relatively small amount of Ni-Resist needed for the insert which is bonded to the aluminum alloy.



Ring bands of NI-RESIST in aluminum pistons

Increase Output...Cut Maintenance

A major problem with engines equipped with aluminum alloy pistons is the high rate of wear that tends to occur in the ring area.

Wear is particularly severe in the top ring groove, which is exposed to the most heat, receives the least lubrication and is attacked by abrasive dust and dirt coming through the intake. "Blow-by" caused by excessive ring groove wear in the aluminum piston means loss of power and increased oil consumption.

There's one answer to these troubles. Wear resistance . . . the answer given by aluminum alloy pistons with ring bands of NI-RESIST®. The high expansion properties of Ni-Resist prevent warping and failure of the joint between the two metals.

You will find it pays to specify aluminum pistons with Ni-Resist ring bands in all heavy-duty engines for truck, bus, locomotive, marine and aircraft, as well as stationary power plant use.

Performance records show increased power per cylinder as well as improved piston life, because Ni-Resist defeats heat, corrosion, metal-to-metal wear and galling. Under current trends to raise engine output by increasing temperatures and using chemically treated fuels, the advantages offered by Ni-Resist mean extra engine economy. A truck fleet operator reports an average of 250,000 miles per set with this type of piston in his vehicles.

Consider Ni-Resist for many other engine applications. These include exhaust valve guides, exhaust seat rings and ball joints, exhaust manifolds...cylinder liners ...connector rings, water pump impellers and bodies.

Several types of Ni-Resist are available to meet a variety of industrial demands. In fact, no other cast metal provides such a useful combination of engineering properties. Get full information . . . mail the coupon now.

The International Nickel Company, Inc.
67 Wall Street, New York 5, N. Y.
Please send me booklets entitled "Engineering Properties and Applications of Ni-Resist" and "Buyers' Guide for Ni-Resist castings."

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TRUCKS, TOO. SHIFT FOR THEMSELVES

with BORG-WARNER Automatic Transmission

Smoother, faster shifting, quicker pick-up, better gas mileage, lower maintenance cost, less driver tension and fatigue . . . these are some of the benefits *now available* in ½ to 1-ton trucks equipped with Borg-Warner Automatic Transmission.

Recognized as the most flexible and versatile automatic in the industry, this outstanding B-W transmission has the over-all equivalent of four speeds—with two gear speeds, a converter, and direct drive. Solid direct drive in high—no slippage, no engine racing. Exceptional rocking ability in snow, mud, slush or sand. 100% downhill engine braking. Easiest of all automatics to service and maintain—entire transmission assembly can be readily removed independent of converter assembly and converter housing.

As for fuel economy, in traffic and door-to-door delivery service the B-W truck automatic has shown from 9% to 40% increase in gas mileage—a bonanza saving in fleet operations.

Designed, engineered and produced by Borg-Warner's Detroit Gear Division, this new truck automatic transmission is readily adaptable to the special requirements of each vehicle on which it is used, and to the widely varying characteristics of different engines. It is a typical example of the engineering skills and production facilities applied to every Borg-Warner product.

185 products in all are made by

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ENGINEERING B-W PRODUCTION

B-W engineering makes it work • B-W production makes it available

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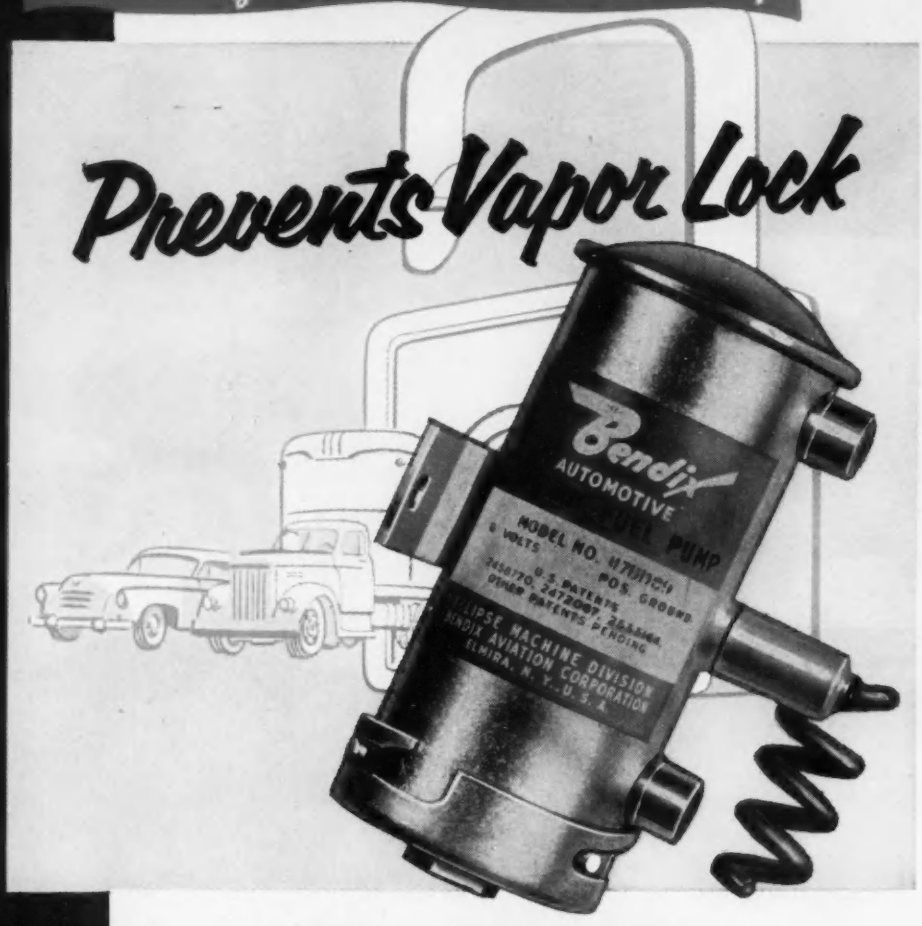
Bendix automotive Electric Fuel Pump

Prevents Vapor Lock



Result

- **better performance**
- **better gas mileage**
- **reduced service expense**

Today it's more important than ever that car and truck manufacturers take every precaution to prevent vapor lock in their vehicles. Modern design and more volatile gasoline contribute immeasurably to increased power and speed; but in achieving these desirable goals heat problems are sometimes increased to the point where vapor lock occurs. Then, gas mileage is reduced, gains in power and speed are nullified, and worst of all, if vapor lock occurs frequently, exhaust valves burn out and expensive overhauls are necessary.

Fortunately car and truck manufacturers can now guard against this hazard. By installing Bendix* Electric Fuel Pumps, vapor lock can positively be prevented and the efficient performance built into the vehicle will be delivered under every operating condition.

In today's competitive market, here is small investment that will pay big dividends in increased customer satisfaction. Descriptive folder available on request.

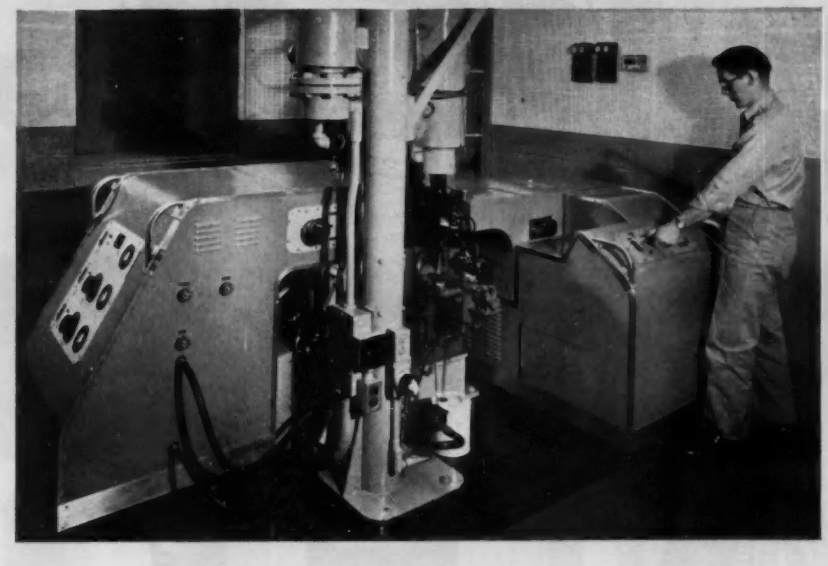
*REG. U.S. PAT. OFF.

Check these Features

- Prevents vapor lock.
- Built-in pressure release—no flooding.
- Instant hot weather re-starts.
- 30 gallons per hour.
- Helium sealed—for longest life.
- Better cold weather starting.
- Only 7 watts power at maximum fuel delivery.

ECLIPSE MACHINE DIVISION

Elmira, New York · *Division of* Bendix AVIATION CORPORATION



The Du Pont Petroleum Laboratory's spectrometer for studying knock. The operator is shown adjusting the amplifier for recording. Part of the single-cylinder engine can be seen in the center of the picture.

Unique spectrometer being used **to develop new facts about KNOCK**

Combustion chamber reactions which contribute to knock have long eluded accurate analysis.

But now, these important, but little understood reactions may be revealed by the spectrometer shown here, which is installed at the Du Pont Petroleum Laboratory.

With this spectrometer, laboratory scientists are taking a new look at the old problem of finding out exactly what goes on in the combustion chamber when a gasoline and air mixture is compressed.

Spectral Analysis

The apparatus is built around a single-cylinder engine having windows on opposite sides of the combustion chamber. Light is passed through the chamber from a source which is located at the left in the picture above. After being filtered through the partially reacted fuel-air mixture, the remaining light rays pass through a multiprism, optical system and are converted into electrical impulses for automatic recording on a strip chart. This spectral analysis covers the complete range of ultraviolet, visible and infrared light.

Since each chemical reaction in the chamber has a characteristic light absorption pattern, the spectrometer can be used to make an analysis of the rapid chemical changes taking place within the chamber. In this way, reactions leading to knock can be followed in the engine and analyzed in detail.

An important part of the equipment is the shutter which is synchronized with the engine crankshaft. This shutter allows light from the combustion chamber to enter the spectrometer only during that part of the engine cycle which is being studied.

What and How

This unique spectrometer, the only one of its kind, was specially developed for the Du Pont Petroleum Laboratory to study exactly *what* causes knock and *how* tetraethyl lead reacts in the fuel to prevent it. Once the answers to these questions have been found, they may point the way to new methods of suppressing knock. After the results of this work have been analyzed, they will be published and made available to the automotive and petroleum industries.

DU PONT
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. . . *through Chemistry*

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Outlasts, outperforms any

NATIONAL Micro OIL

Lowest Torque

Highest Lubricity

No Measurable Leakage

Runs Cool, Lasts Longer

Sealing Lip Stores Oil

New National Micro-Torc Oil Seals, developed and offered only by National, absorb less power and last longer than any leather oil seal ever made. Properly employed, National Micro-Torc seals have *no measurable leakage throughout service life.*

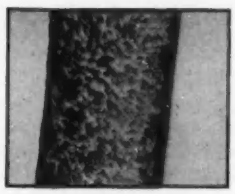

Figure 1
National Micro-Torc sealing member with "storage action"

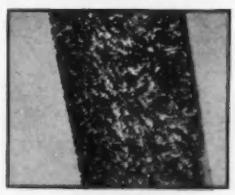

Figure 2
Leather seal impervious because of complete rubber impregnation

National Micro-Torc sealing members are coated with an elastomer of high lubricity through which lubricants cannot pass, (Fig. 1). However the body of each sealing member retains its natural porosity. Thus, Micro-Torc sealing members absorb and store lubricant while permitting none to escape. This feature alone makes Micro-Torc the outstanding seal for starved or semi-starved applications.

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performance records!

leather oil seal ever made!

-Torc

TRADE MARK

SEALS

This is in sharp contrast with present-day leather seals which tend to saturate and leak, or completely rubber-impregnated leather seals (Figure 2) which are impervious to oil and can neither absorb nor store lubricant for periods when lubricant is not otherwise supplied.

TESTS SHOW SUPERIORITY

In a continuing series of identical 1,000 hour tests at National Motor Bearing Co., the marked superiority of National Micro-Torc Oil Seals over present day leather seals has been clearly demonstrated. Completely rubber-impregnated seals showed an average leakage of 1 to 5 grams per day. In addition, these seals hardened and became brittle after only 200 hours operation at 170° F.

By contrast, 90% of Micro-Torc seals tested *had no measurable leakage at all.* (Figure 3) Test conditions throughout the 1,000 hours were identical in every respect. At the end of the run, *every National Micro-Torc Seal was flexible and fully operative.*

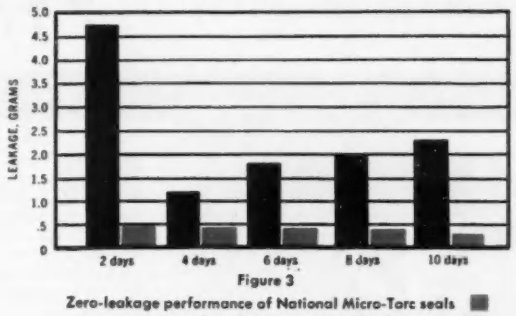


Figure 3

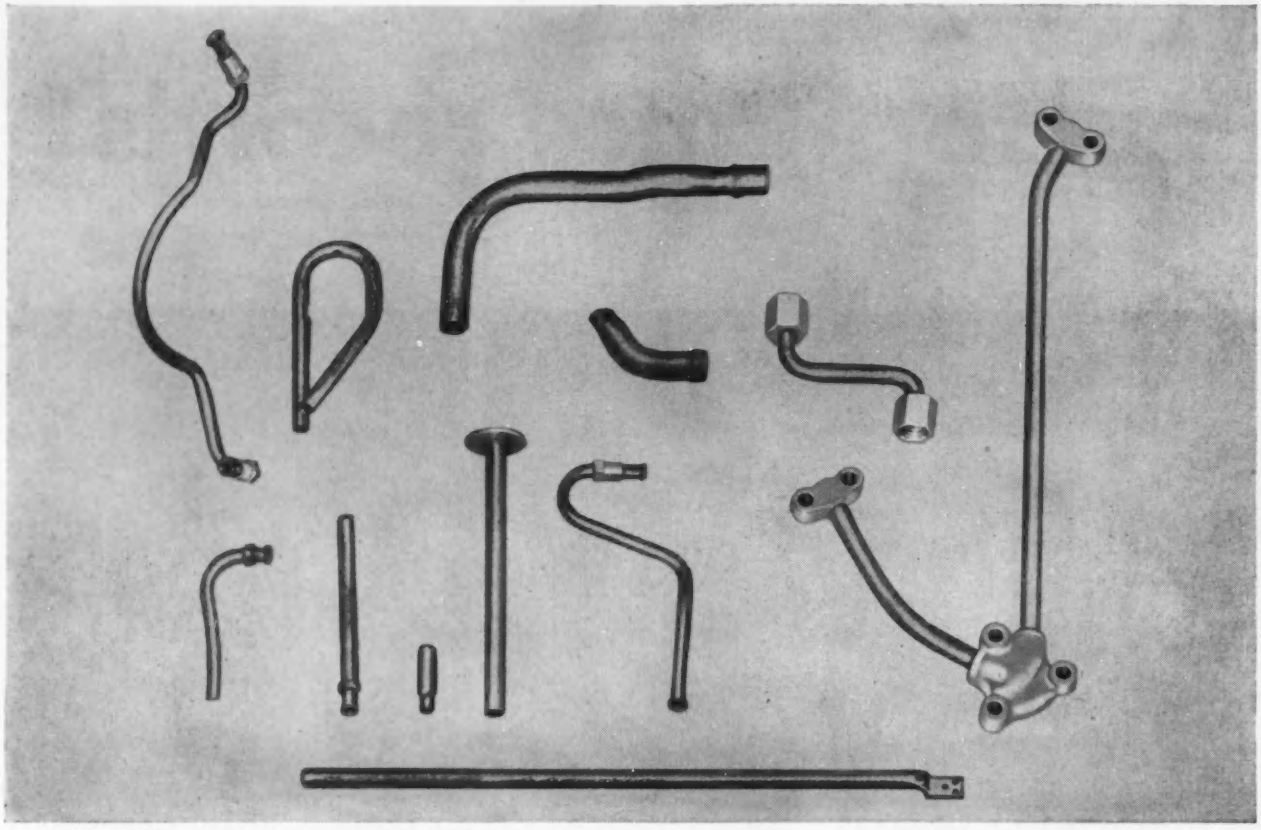
Zero-leakage performance of National Micro-Torc seals ■ in comparison with rubber-impregnated leather seals ■

TECHNICAL BULLETIN

Describes National Micro-Torc in detail, contains test results, performance charts. For your free copy, write Dept. A.

3122

NATIONAL MOTOR BEARING CO., INC.
General Offices: Redwood City, Calif.
Plants: Redwood City, Calif.; Van Wert, Ohio



A few samples of the wide variety of tubing parts produced for Bundy customers. Leakproof Bundyweld offers you absolutely dependable function in oil, gas, transmission lines, other vital tubing lifelines.

Bundyweld lifelines help farm machines bring in a speedy, profitable harvest

WHY BUNDYWELD IS BETTER TUBING

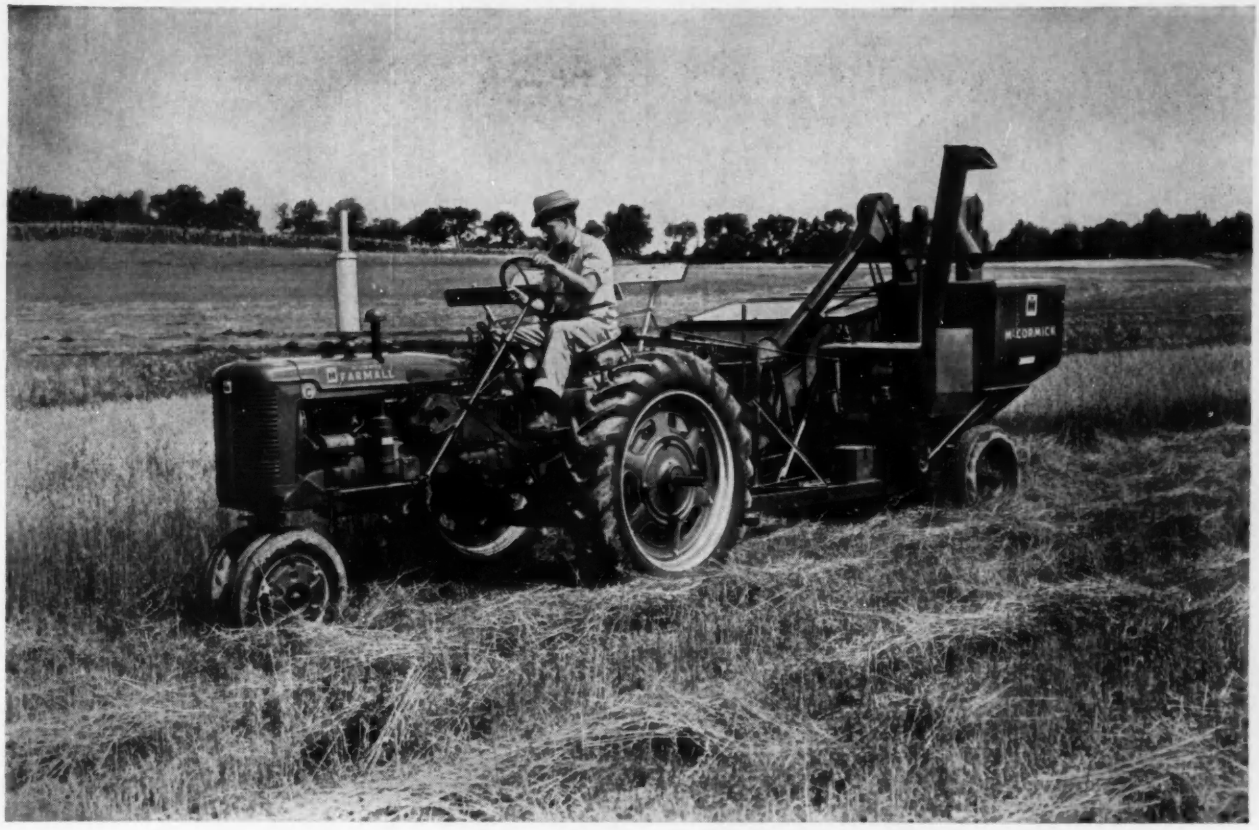
Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.



Above, International Harvester's McCormick No. 64 Harvester-Thresher, pulled by a McCormick Farmall tractor. Bundyweld parts like those pictured at left help assure this leading farm-machine manufacturer of dependable tubing performance.

Speed and efficiency are imperative at harvest time. That's why International Harvester's McCormick No. 64 balanced-flow harvester-thresher shows to such advantage, combining speedy, trouble-free operation with peak efficiency in saving more of the crop.

Naturally, International Harvester requires a dependable tubing for its famed products. *That's why Bundyweld Tubing is used for so many vital tubing lifelines.*

Bundyweld is leakproof by test; thinner walled yet stronger; can withstand heavy vibration fatigue, punishing wear; has high bursting strength; takes easily to standard protective coatings. It's the only tubing double-walled from a single metal strip, copper-brazed throughout 360° of double-walled contact.

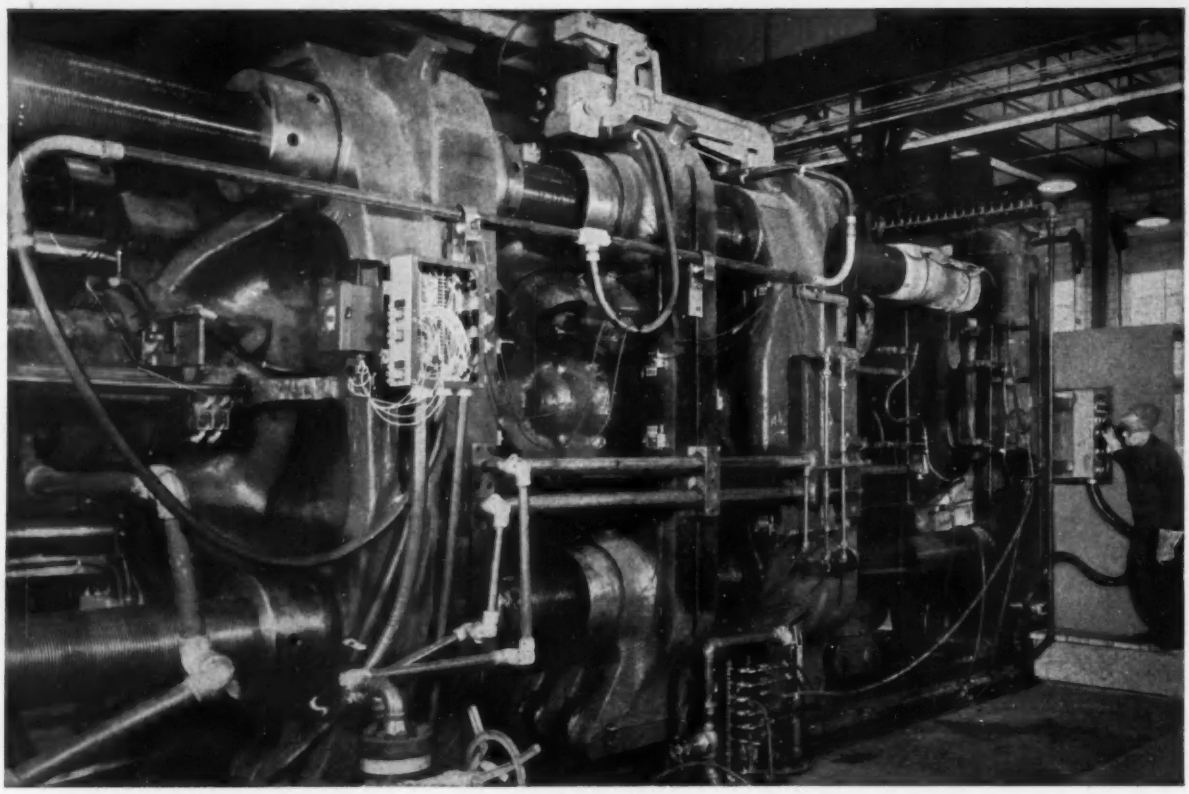
Other Bundy plus-services you'll appreciate: expert engineering assistance; the industry's most technically advanced fabrication facilities; custom-packaging of orders; prompt, on-schedule deliveries. Let us help you with your farm machines, automobiles, trucks or buses. Call, write or wire.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Bundy Tubing Distributors and Representatives: *Bridgeport, Conn.:* Korhumel Steel & Aluminum Co., 117 E. Washington St. • *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, New Jersey:* A. B. Murray Co., Inc., Post Office Box 476 • *Los Angeles 58, Calif.:* Tubesales, 5400 Alcoa Ave. • *Philadelphia 3, Penn.:* Rutan & Co., 1717 Sansom St. • *San Francisco 10, Calif.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 4755 First Ave., South • *Toronto 5, Ontario, Canada:* Alloy Metal Sales, Ltd., 181 Fleet St. East.
Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.



The leader, Doehler-Jarvis, takes another step forward...a Giant 72-inch die casting

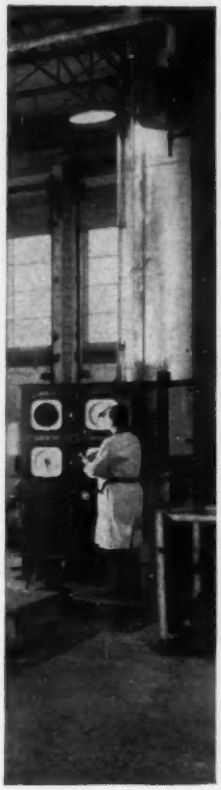
In one tremendous thrust Doehler-Jarvis has broken through the "size barrier" that limited pressure-cast metal components to comparatively small dimensions and light weights.

The new 250-ton machine recently put into operation by Doehler-Jarvis can produce aluminum castings weighing up to 75 lbs. and measuring practically anything that will go between the tie-bars. Adapted to zinc, it can handle shots up to 200 lbs.

Ever since the invention of the first practical pressure die casting machine about a half century ago, many people have felt that "Doehler and die casting" were synonymous. It's common knowledge that just about every "first" in this fast, efficient process of forming metal parts has been credited to the Doehler organization.

This new machine is, in a way, the culmination of fifty years of effort to widen the horizon for die cast components. And the effort will not stop here.

Why don't you put Doehler-Jarvis to work on your metal-parts problem?



Castings are removed from machine by mechanical "arms." Cable reel flanges shown here weigh 41 lbs. as they come from the die, and 31 lbs. after gate and flash are removed.

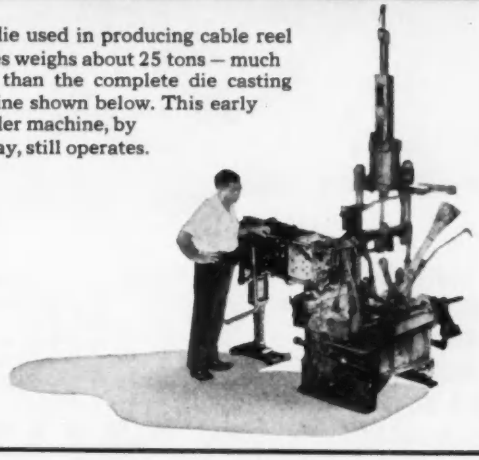
This huge machine "eats up" about a ton of aluminum per hour. An automatic ladle was developed to handle this large metal consumption.

Stride...with this machine

Doehler-Jarvis Division
of
National Lead Company
General Offices: Toledo 1, Ohio

*Reg. U.S. Pat. Off.

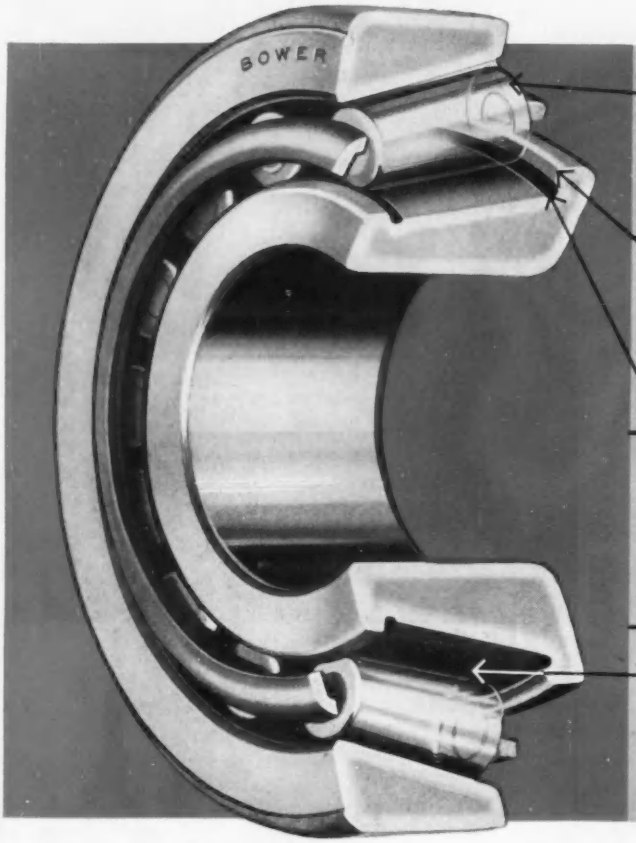
The die used in producing cable reel flanges weighs about 25 tons – much more than the complete die casting machine shown below. This early Doehler machine, by the way, still operates.



Here's how BOWER Spher-o-honed design lengthens bearing life... cuts maintenance costs!

The Bower tapered roller bearing design features shown on this page are vitally important to every bearing user. For they illustrate the high quality, precision workmanship and close attention to engineering detail that go into *every* Bower bearing. Even more important, these Bower design features will give you significant bearing advantages such as reduced wear, longer bearing life and lower maintenance requirements. They've been thoroughly *proved* by extensive use in virtually every type of bearing application. If your product uses bearings—whatever it may be—specify Bower now. Or better yet, call in a Bower engineer while your product is still in the blueprint stage.

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN



● **SPHERICAL ROLLER HEADS ARE GENERATED TO THE CONTOUR THEY ACQUIRE IN THE COURSE OF WEAR.** This helps Bower bearings hold adjustment and pre-load longer and better. Normal running-in time is virtually eliminated.

● **HIGHER FLANGE PROVIDES A LARGE, TWO-ZONE CONTACT FOR ROLLER HEADS,** thereby reducing unit pressure. This exclusive Bower feature improves roller alignment, greatly reduces wear and practically eliminates resultant "end play."

● **LARGER OIL GROOVE GIVES POSITIVE LUBRICATION** at the critical point—where the roller head thrusts itself against the cone flange. Here Bower design provides a larger recess that holds a generous supply of lubricant—increasing efficiency and decreasing wear.

● **PRECISION RACES PROVIDE QUIETER, SMOOTHER OPERATION.** A Bower-developed grinding and honing process provides a micro-smooth surface of hard, crystalline base metal. In this way, close-tolerance precision is built-in to stay! No final adjustment is needed!

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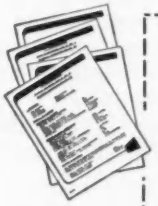

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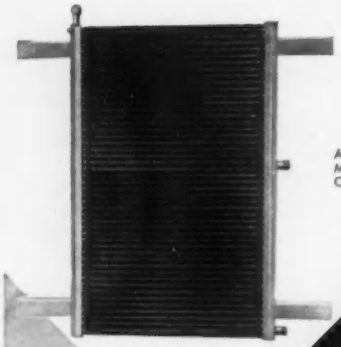

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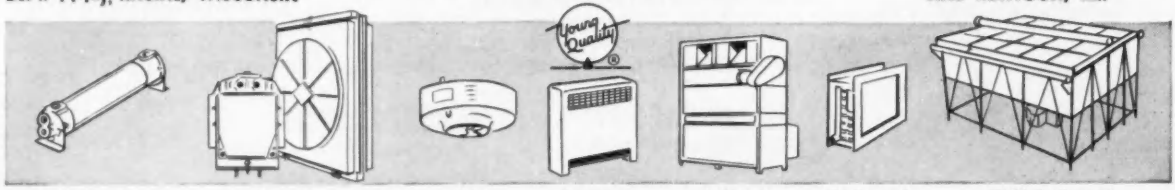

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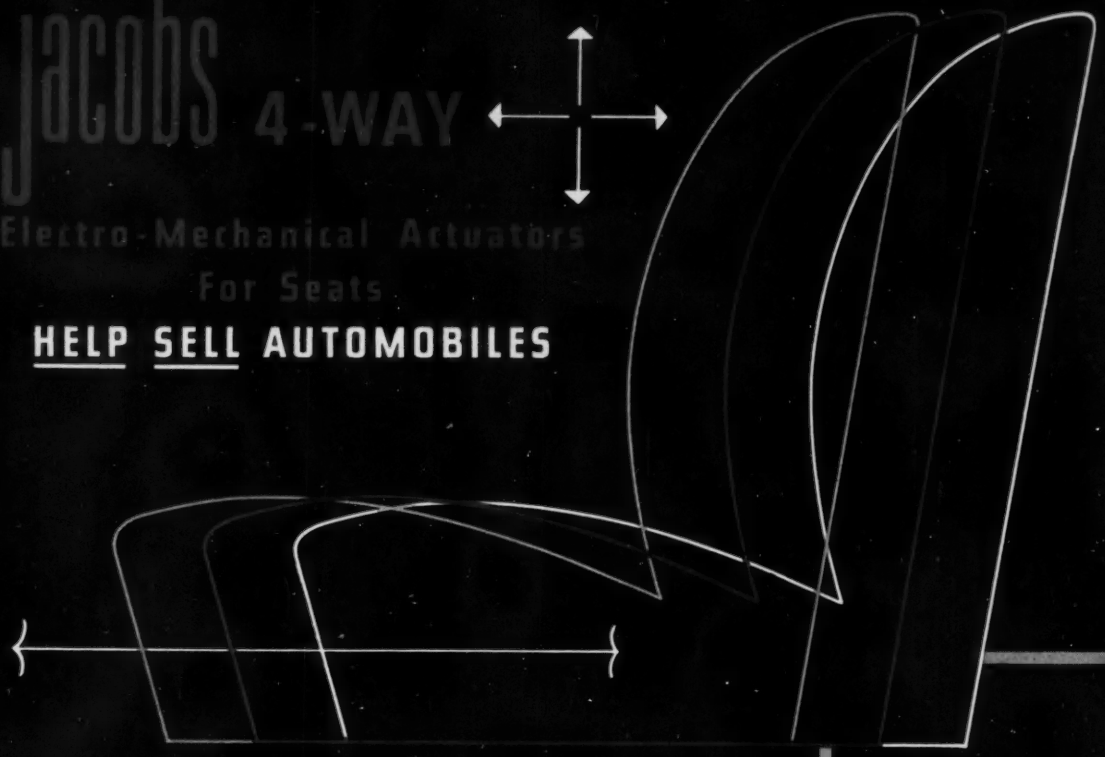

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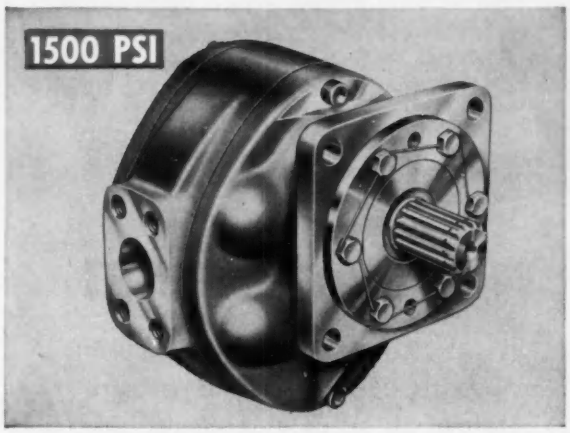

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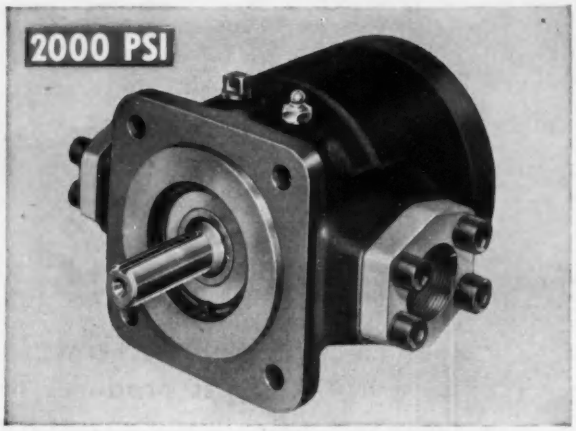

SERIES PF-100 VANE-TYPE PUMPS

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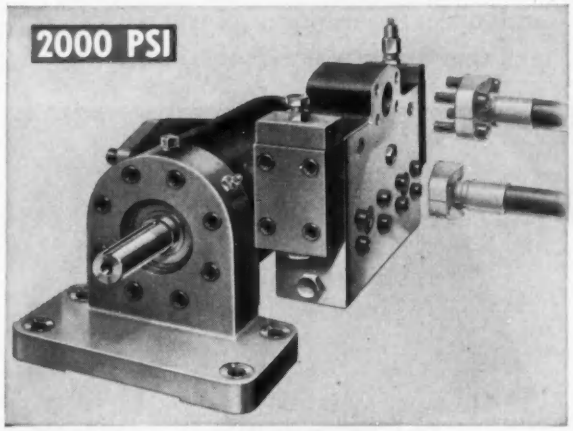

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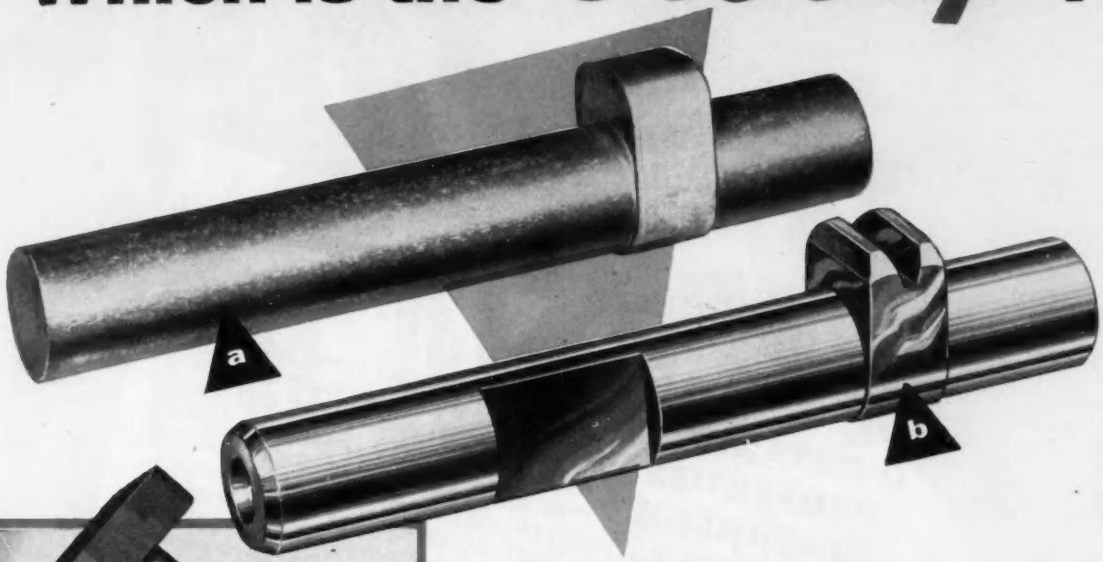

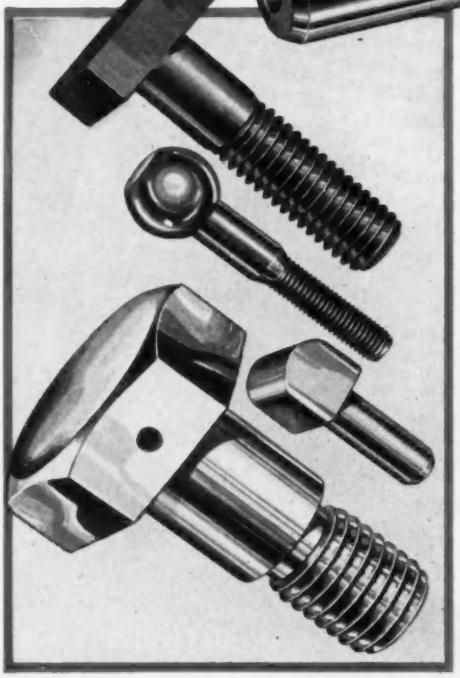

...it could be both _____ made by fast economical CleCap processes

It just might pay you to take a good look at the special parts you're buying that could be made more economically by CleCap's hot heading or cold extrusion processes. Quite a number of our customers have done it... and they like what happened.

The forged blank (a) above was produced for one user. He finished it as it's shown at (b). CleCap pre-forms your non-standard parts for further shaping and machining in your plant or manufactures them complete, ready for your assembly line. You'd be surprised at all the different shapes we've turned out.

You can save yourself tooling and machine time. Take a look at what CleCap offers—engineering skill and experience in applying high production methods and machines to your problems. Anyway, write for folder, "Specials by Specialists".

Cleveland *Top Quality* Fasteners

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Hexagon Head Cap Screws • Socket Head Cap Screws—Plain & Knurled; also Flat and Button • Flat Head and Fillister Head Cap Screws • Place Bolts • Structural Bolts • Tractor Bolts • Square Head Set Screws • Socket Set Screws • Milled Studs

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Originators of the Kaufman DOUBLE EXTRUSION Process

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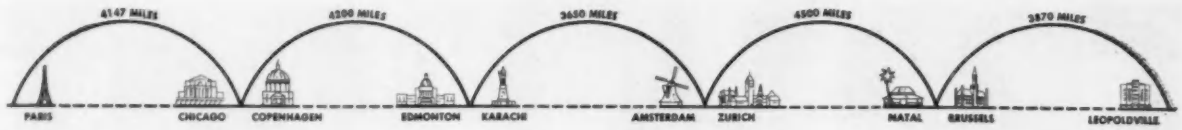

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New DOUGLAS DC-7C

Adds 1000 miles to non-stop flight limits...

Adds up to 70 mph to cruising speed

Here is the first truly Intercontinental passenger airplane. This Douglas distance champion will carry competitive payloads up to 5000 miles non-stop . . . makes possible unrefueled flights like those illustrated...and because of its range and speed, promises to revolutionize air travel and airline operations between continents.

Longer wings to carry more fuel also allow engines to be moved further away from the cabin, making the DC-7C even more *quiet* and *comfortable.*

Already ordered in quantity by Pan American World Airways, these new model Douglas transports are scheduled to begin intercontinental service in 1956.

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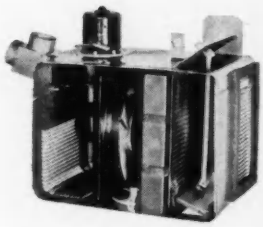
a new heater defroster

specially designed by EVANS for large truck cabs

MODEL ED-90



Removing front cover exposes all elements for easy servicing. Note the exclusive Evanair 9" Die-cast fan, the interlocked dampers for mixing recirculated and fresh air, the extra thick 2" core, the built-in high pressure blower with extra large motor and the over-all heavy duty construction.

- 100% fresh air or mixed with recirculated air as driver desires
- Powerful built-in pressure type defroster blower 72.2 CFM of hot air at windshield
- Controlled summer comfort, 100% fresh air with water shut off
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- Plus all these Evans standard features: Distinctive Styling, Compact Design, Modern Appearance, Built-in Durability, High Efficiency, Engineered-to-match motors, fans and cores, Easily Accessible Components, Full-Year (or 50,000 mile) Warranty.

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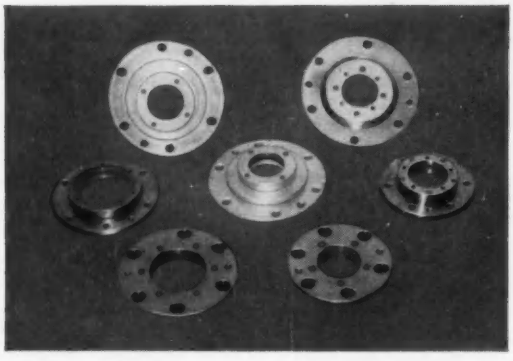

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W&T Precision Absolute Pressure CONTROLLER . . .
. . . coupled with electronic relay unit (not shown)
To Control the Absolute pressure of closed systems within narrow limits.

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. . . Accuracy: 1 part in 300 of full scale
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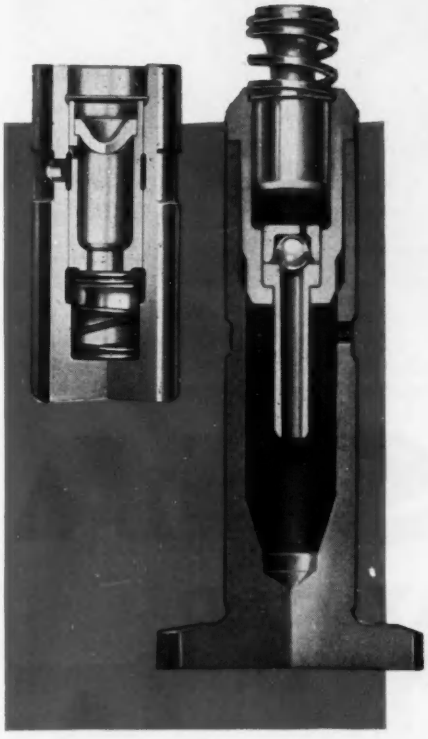
Eaton Hydraulic Valve Lifters

ARE ELIMINATING

"LASH WORRIES"

FOR TRUCK MANUFACTURERS



These types of Eaton Hydraulic Lifters are used in some of the country's best known motor trucks, recognized for excellence of performance and minimum upkeep.

Too little lash means valve burning; too much means breakage; maintaining proper lash is costly in labor and in lost vehicle time. Truck manufacturers are eliminating these lash worries for themselves and their customers by using Eaton Hydraulic Valve Lifters in their engines.

Performance records covering trucks using Eaton Hydraulic Valve Lifters prove that the small additional cost is paid for hundreds of times over in improved performance, freedom from adjustment, and longer valve life.

Eaton Hydraulic Valve Lifters are available in all designs and face materials, to meet the specific requirements of each application.

Eaton engineers will welcome an opportunity to discuss the application of Eaton Hydraulic Valve Lifters with original equipment manufacturers.

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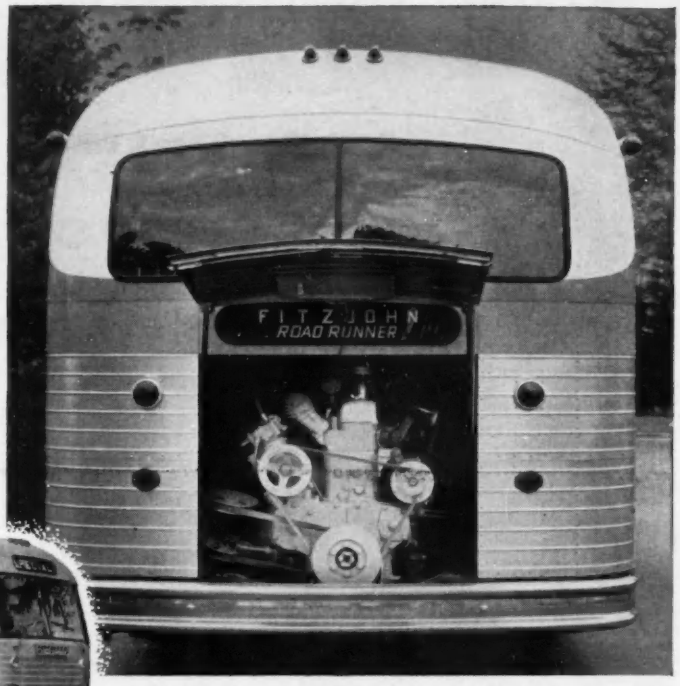
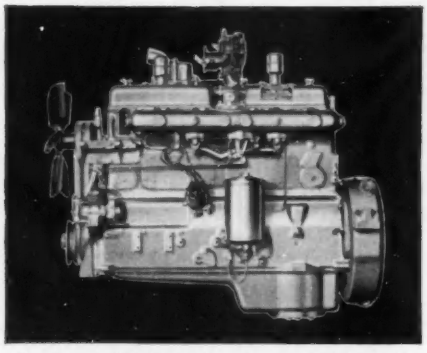
Our Equipment is used on The ROAD-RUNNER FITZJOHN INTER-CITY COACH

quick pick-up ...fast ...smooth ...powerful



The Fitzjohn Road-Runner coach has its Waukesha 140-GKB Engine mounted at the rear in longitudinal position—easily accessible through the rear center and two side service-doors of the insulated, fire-proofed compartment.

WAUKESHA



Typical WAUKESHA Model 140-GKB Gasoline Engine
six cylinders, 4½-in. bore x 5½-in. stroke
525 cu. in. displacement; 177 hp. at 2600 rpm.

the PAYLOAD POWER PLANT

What makes the Road-Runner run—the fast pick-up-and-go, mile-making schedule-keeping Waukesha Engine with its swift, safe, smooth, sure power.

Waukesha designed-and-built for high-speed highway, inter-city bus transport—with all the well-known Waukesha payload performance and economy features...

Counterbalanced crankshaft, vibration dampened, 3¼-in. 7-bearing, specially hardened... precision, extra high capacity bearings... overhead valves with Stellite-faced exhaust valves and seats... aluminum alloy pistons... removable wet-type cylinder sleeves... full pressure oiling... and many other high power output, low maintenance advantages. Send for Bulletin 1079.

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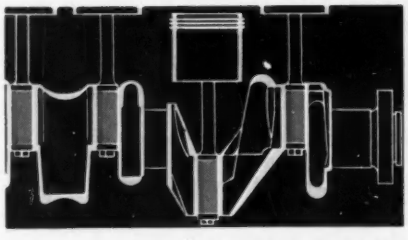
WAUKESHA MOTOR COMPANY, WAUKESHA, WIS. • NEW YORK • TULSA • LOS ANGELES

moraine-400 bearings

handle more power... with less bearing length



The extraordinary toughness of Moraine-400 bearings permits the use of shorter bearings and journals, making room for thicker crankarms. With Moraine-400, bearing length ceases to be a limiting factor in engine design.

Yes, now you can step up the horsepower and torque of a given engine without increasing crankshaft bearing area. Moraine-400 bearings permit you to make journals shorter and heavy-up the shaft between them. Result: a more rigid shaft capable of carrying greater piston loads.

Moraine-400's superior load-carrying ability is due to the extraordinary toughness of a new bearing metal developed by General Motors-Moraine research over a ten-year period. This aluminum-base alloy, bonded to a steel back, is so tough that Moraine-400 is consistently outperforming other bearings.

Moraine-400 bearings operate equally well on oil-hardened and Tocco-hardened shafts, and are outstandingly good in such qualities as embedability, conformability, and resistance to corrosion.

Note: Moraine also makes the famous Moraine-100 bearings—now used as original equipment on many of the nation's finest cars and trucks.

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For trucks, trailers, hoists, tractors, harvesters, cranes, buses, shovels, mixers, machinery, etc.

Offers you these 7 exclusive advantages!

1. New Simplicity! Only 8 simple parts. Shoes and springs are completely interchangeable. For instance — brake shoes can be "slapped in." Position of the shoes makes no difference . . . it's *impossible* to install them incorrectly. Simplifies stocking—only 6 different parts required to completely replace the brake.

2. No Lubrication Required! Maintenance reduced to the absolute minimum. No skilled help needed because it's "foolproof" to service and install. No inside adjustment necessary.

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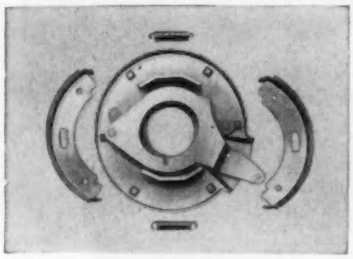
4. Lightest Weight! This new development by TDA is in a class by itself. For example: the 13-inch drum size weighs only 40 lbs. as against 80 lbs. for an ordinary band brake!

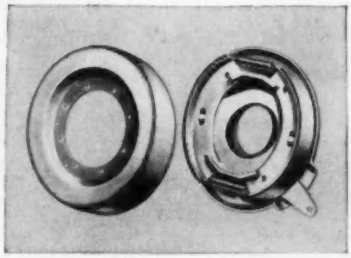
5. Less Cost! These brakes use lightweight stamped steel shoes of new design as against ordinary heavy, more costly cast shoes. Wear longer with increased braking power.

6. New Balanced-Type Design! Exerts equal torque —in both directions. Balanced pressure makes both shoes do same amount of work. Brake linings have uniform wear pattern . . . constant, smooth performance.

7. Five Times Longer Brake Lining Wear, proved in actual road and work tests. This means less maintenance costs for operators . . . less inventory to stock. For instance: one manufacturer plans to use *three* of these new brakes to replace *five* types now employed.



Look how simple it is! No tricky assembly. Just remove two springs and lift out shoes. Put it together in minutes. No adjustment of brake required.



Here's the combination that gives this brake its outstanding superiority. Fewer parts to wear, to stock—longer life—less maintenance—lower cost.

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Please send me complete new literature on this new all-purpose brake. I am outlining my special braking problem on the attached letterhead.

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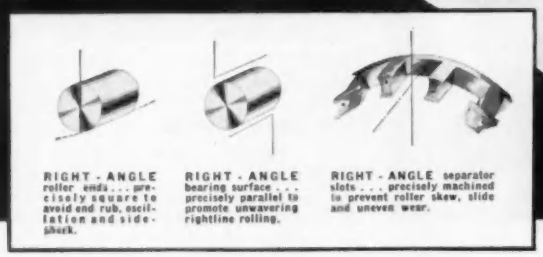
Because every surface is precisely square . . . precisely parallel. No skew . . . No skid . . . No oscillation



RIGHT-ANGLE roller ends . . . precisely square to avoid end rub, oscillation and sideshock.

RIGHT-ANGLE bearing surface . . . precisely parallel to promote unwavering rightline rolling.

RIGHT-ANGLE separator slots . . . precisely machined to prevent roller skew, slide and uneven wear.

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Loaded at right angles, with no diagonal components to impose skew forces. Precisely square and parallel from every surface aspect. The solid cylindrical rollers of Rollway Right-Angle Roller Bearings follow the right-line motion of Newton's first law, providing *unwavering orbital rotation around the shaft.* Internal friction and heat are held to a minimum. Maintenance attention and replacement costs are low . . . life and load-performance qualities surprisingly high.

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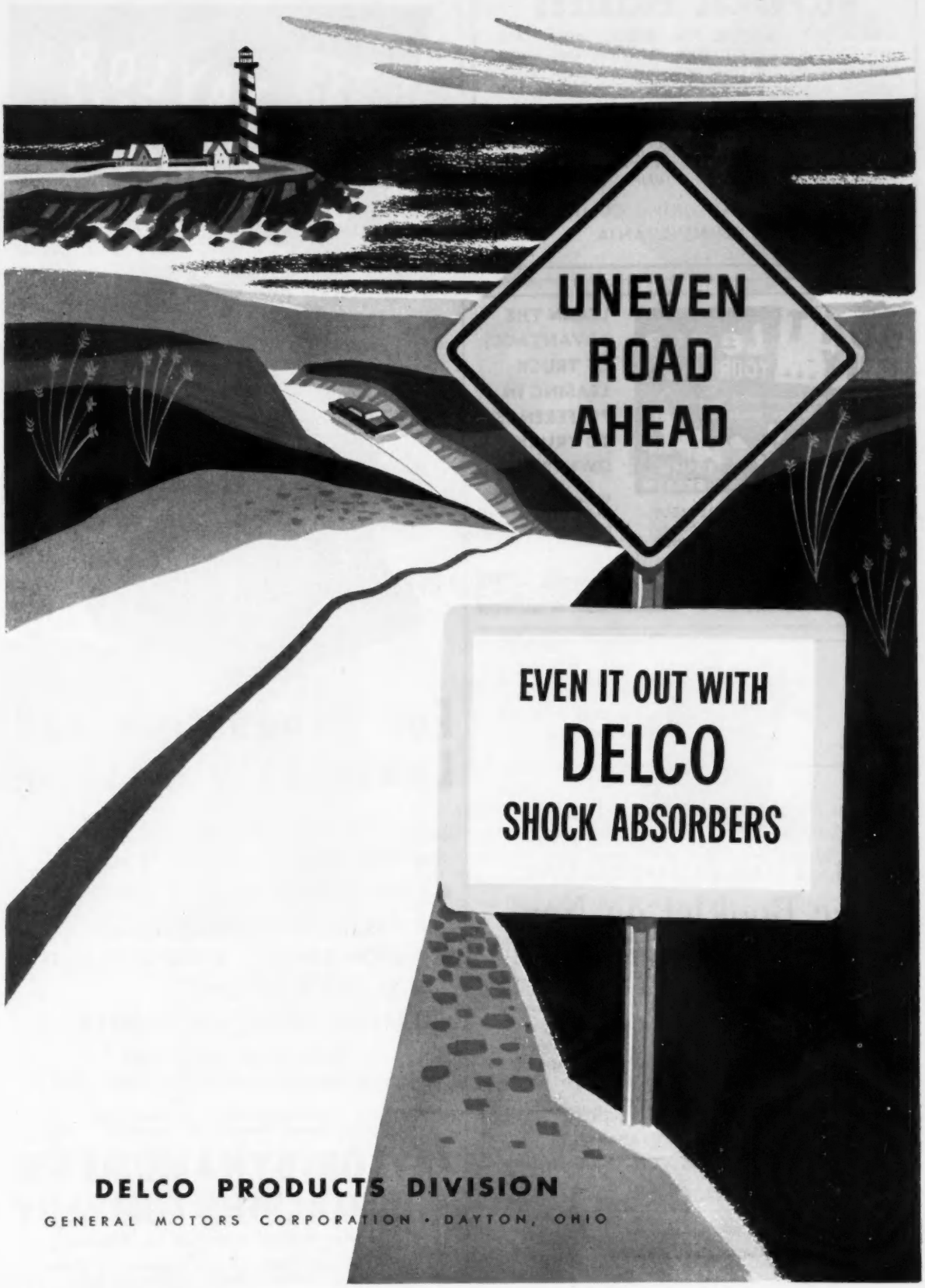
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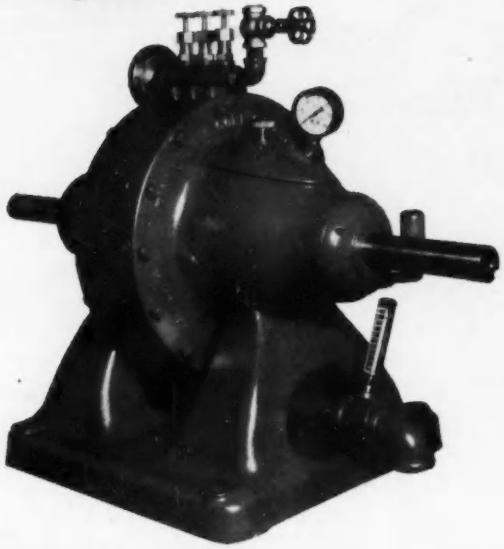

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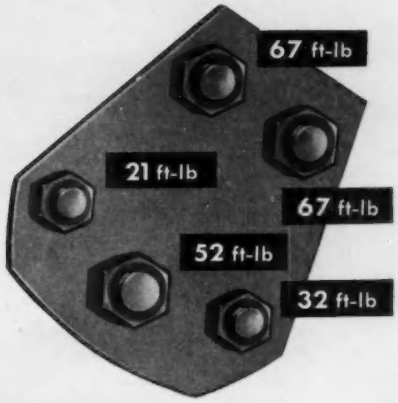
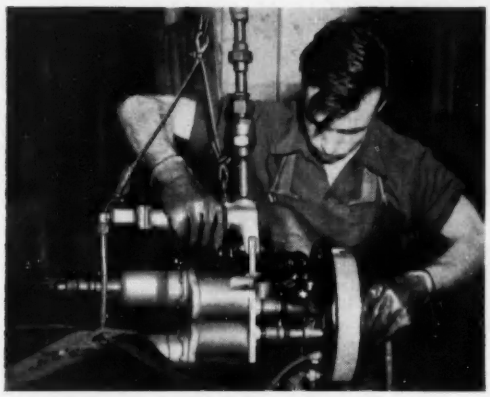


NEW!

KELLER MULTIPLE NUT SETTER

with Individual Torque Control



On an automobile assembly line, the Keller Multiple Nut Setter runs two nuts which attach the front brake plate to the spindle. Spot checking for quality control showed that in 97% of the cases the upper nut held to 48-50 ft-lb, and the lower one to 74-79 ft-lb—a much narrower range than the tolerances allowed by engineering.

Now You Can . . .

- ★ **Set 2 to 6 nuts at once**
- ★ **Control torques accurately up to 120 foot-pounds**
- ★ **Select torques individually**

This newly developed air tool sets two to six nuts simultaneously, and controls the torque on each to such accuracy that hand torquing is a thing of the past. Torque adjustment is built into the head of each spindle, so that each nut is controlled individually.

Spindles are held by a mounting plate designed to fit the bolt pattern. Mounting plates can be made in any toolroom or machine shop. Offset drive spindles allow close spacing where nuts or bolts are closely clustered.

Full information is contained in a new catalog section . . . write for a copy.

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Detail View of New
Spicer Center Bearing Mounting

50 YEARS OF
Spicer
SERVICE

DANA CORPORATION

what a relief!

Revolutionary New Spicer Center Bearing Mounting for Spicer Propeller Shafts

REDUCES VIBRATION UP TO 80%
LENGTHENS TRUCK AND PARTS LIFE
LESSENS DRIVING FATIGUE

Happy days ahead, for many drivers of 1955 trucks!

The new Spicer Center Bearing Mounting has put the shackles on destructive, annoying propeller shaft vibration ordinarily transmitted through center bearing supports!

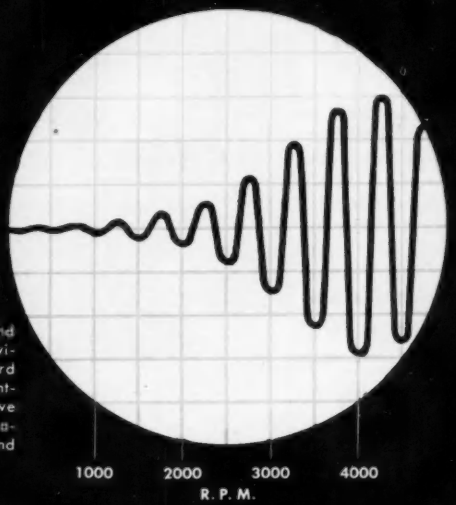
Gone is the propeller shaft hum . . . the buzz . . . the penetrating, nerve-wracking oscillations that weary the driver's body and wrack the truck's frame.

The Spicer Center Bearing Mounting embodies a revolutionary combination of ball bearing and low-frequency rubber. This achieves remarkably low vibration transmissibility at driving speeds. It dampens . . . deadens . . . absorbs nearly all the vibration disturbances transmitted to it from the drive line.

The new Spicer mounting is an outstanding engineering advancement. It is as momentous and far-reaching in effect as the now-famous soft-rubber engine mounting principle. One ride in a truck equipped with this Spicer unit will quickly prove its driver-saving, truck-saving ability.

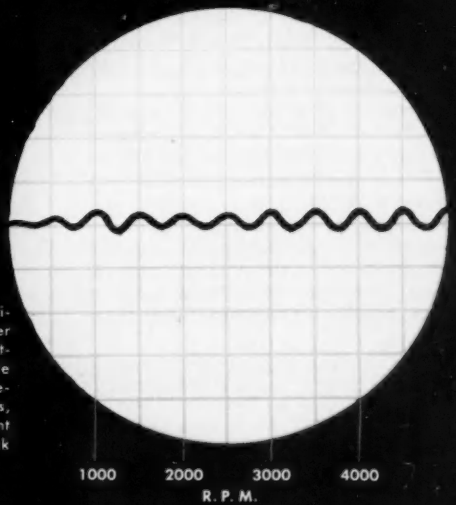
The new Spicer Center Bearing Mounting is available for original truck equipment, as an integral part of the Spicer Propeller Shaft assembly. It is another Spicer engineering "first," typical of Spicer pioneering that has been dedicated to the advancement of the automotive industry.

Oscillometer Recording of Standard Center Bearing Mounting



Extreme variation and high frequency of vibrations in standard center bearing mounting cause excessive and destructive vibration to both truck and driver.

Oscillometer Recording of New Spicer Center Bearing Mounting



Small modulus of vibration in new Spicer Center Bearing Mounting indicates absence of annoying, trouble-making frequencies, assuring more pleasant and profitable truck operation.

TOLEDO 1, OHIO

SPICER PRODUCTS: TRANSMISSIONS • UNIVERSAL JOINTS • PROPELLER SHAFTS • AXLES • TORQUE CONVERTERS • GEAR BOXES • POWER TAKE-OFFS • POWER TAKE-OFF JOINTS • RAIL CAR DRIVES • RAILWAY GENERATOR DRIVES • STAMPINGS • SPICER and AUBURN CLUTCHES

We give truck axles a brutal

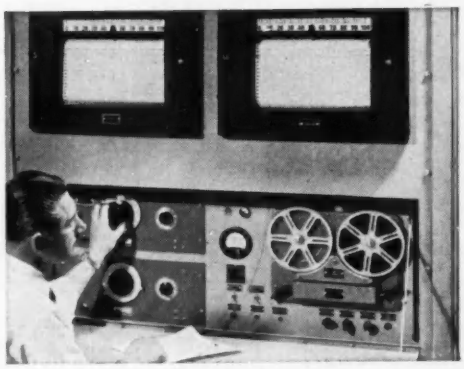
in the new Timken-Detroit indoor proving ground ...and only Timken has it!

We smash, twist, jerk and over-load them. Match every imaginable hauling situation. Then add a few ruinous tricks of our own.

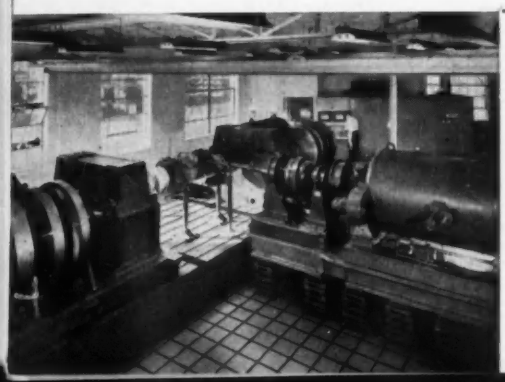
It's done on purpose. So we can tell you in advance that a Timken-Detroit axle can take a more brutal beating on the job it was designed for than any other axle made.

To prove it, we condensed a multi-thousand acre proving ground into one room. In it, our engineers can apply 50 years of experience in building axles for trucks, buses and trailers. Here axles and gearing are subjected *indoors* to any possible *outdoor* hauling condition. Axle performance is measured and analyzed under absolute scientific control!

Such research means longer axle life; less maintenance, repairs and down-time; lower operating costs; fatter profits. No wonder Timken-Detroit axles are the choice of manufacturers and owners everywhere!



This is our "truck driver," he works in the "Torture Chamber." Above him are graphs showing speed and torque performance under any operating condition he chooses . . . soft ground at full load . . . mountains . . . express highways or side roads. With special dials, recorders and electronic devices, he actually *drives* the axle with scientific accuracy from his chair!

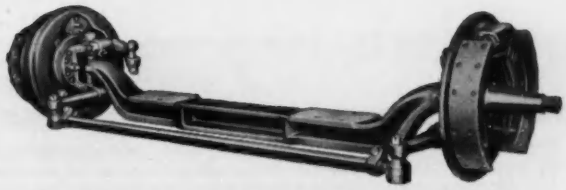


How TDA proves axle quality in this "Torture Chamber."

We take one of our axles and put it on the "block". . . . then duplicate the roughest hauling condition, hour after hour, day after day . . . such as simulating 500,000 miles of toughest driving in just a few days. Or we "dream up" a test like going up hill with a full load at 45 m.p.h. from California to New York—*non-stop*. There is no other axle testing like it in the world!

He's on the highway. He needs Timken-Detroit axles. Identical axles in our indoor proving ground are subjected to tests so rugged they're comparable to a half-million miles or more of high-speed, non-stop, uphill-downhill operation with capacity load . . . hour after hour, 24 hours a day, for days! Only Timken-Detroit "Torture-Tested" axles can take this brutal treatment—to assure top performance—make more money per load!

beating

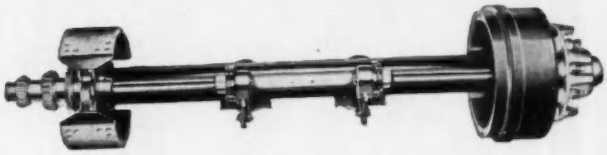


Timken-Detroit "Letter Series" Front Axles

Here is easy, positive steering control. A little man can handle a large rig with TDA front axles as easily as a big 210-pound, six-footer, at fast or slow speeds . . . on smooth or rough roads. No wheel kickback. Tractor hook-ups have smallest possible turning radius—greatest maneuverability.

Timken-Detroit "Letter Series" Rear Driving Axles

Hypoid gearing for truck axles was pioneered by Timken-Detroit. And only Timken-Detroit has Hypoid gearing in a complete "family" of 7 basic axle capacities—in the entire range of medium and heavy-duty requirements. This advanced-related design incorporates the same features of construction and interchangeability in a choice of 3 types of Hypoid final drives using the same axle shafts and housing—single-speed; single-speed double-reduction; and two-speed double-reduction units.



Timken-Detroit Tubular Trailer Axles

Famous for their light weight. Produced in the largest, most modern axle plant in the world. Lightweight Fabricated Brake Shoes with Econoliners for greater wear, longer service. Alloy steel spindles electrically welded to tubular housing—with welding guaranteed for the life of the axle. Lightweight Nylon Bushings in Brake Camshaft Assemblies.

TIMKEN Detroit AXLES

TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN

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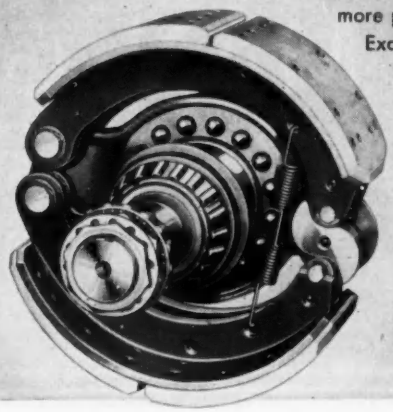
TRADE MARK REGISTERED

"TORTURE-TESTED"
to Save Money on the Job

WORLD'S LARGEST MANUFACTURERS OF AXLES FOR TRUCKS, BUSES AND TRAILERS

New TDA brake shoes save up to 40 lbs. per axle



• Lightweight, pressed steel construction to give you more payload plus long wear and safety. Exclusive ¾" TDA "Econoliner" brake liners held rigidly by 12 deep-set rivets per block—*not bolts*. Liners are thickest at center where greatest wear occurs—taper down at ends. Result—longer wear, greater stopping ability. New cam roller mountings never seize or brinnel. Light nylon camshaft bearings wear up to 4 times as long! It's America's new brake shoe!

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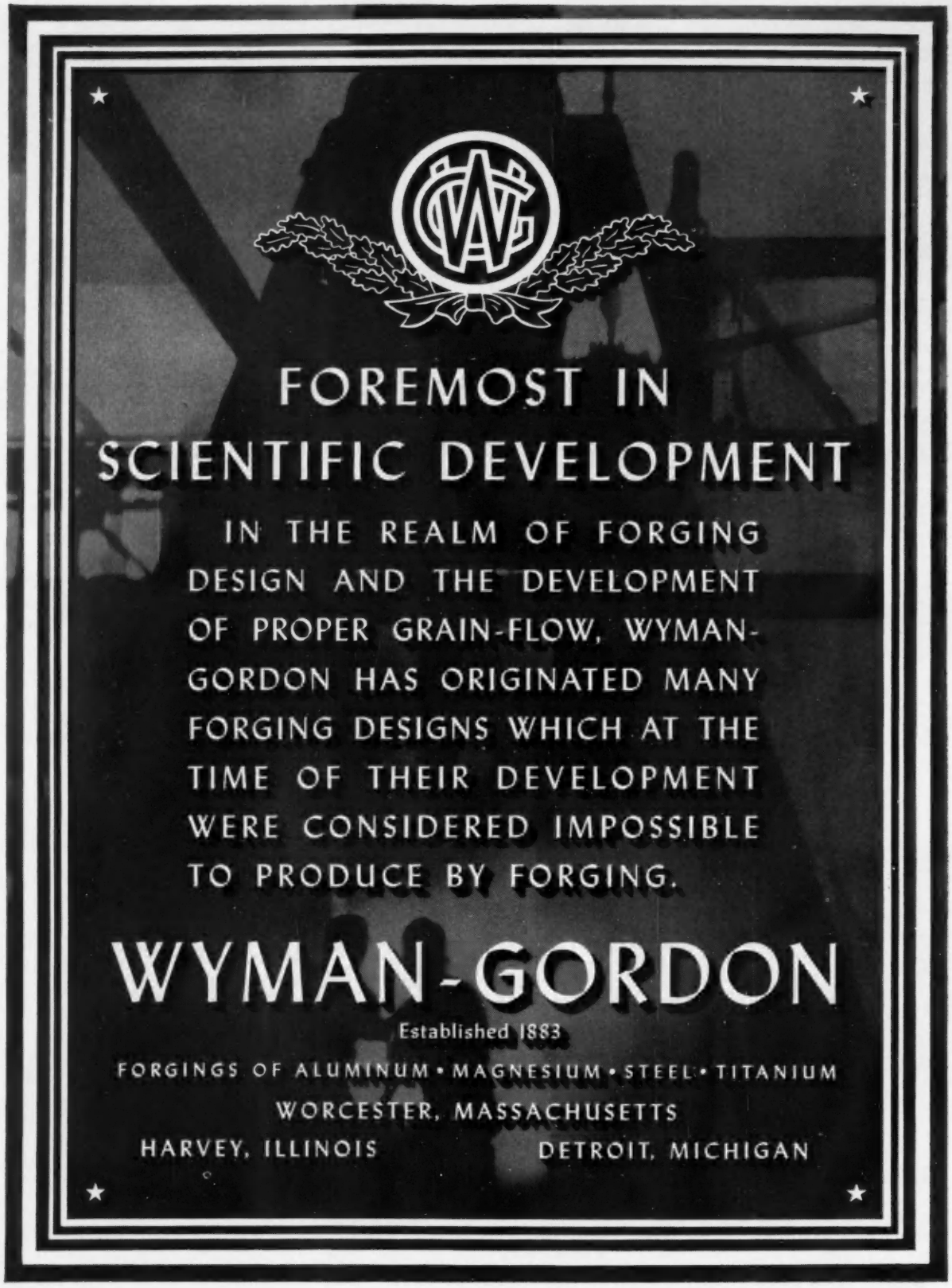
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IN THE REALM OF FORGING DESIGN AND THE DEVELOPMENT OF PROPER GRAIN-FLOW, WYMAN-GORDON HAS ORIGINATED MANY FORGING DESIGNS WHICH AT THE TIME OF THEIR DEVELOPMENT WERE CONSIDERED IMPOSSIBLE TO PRODUCE BY FORGING.
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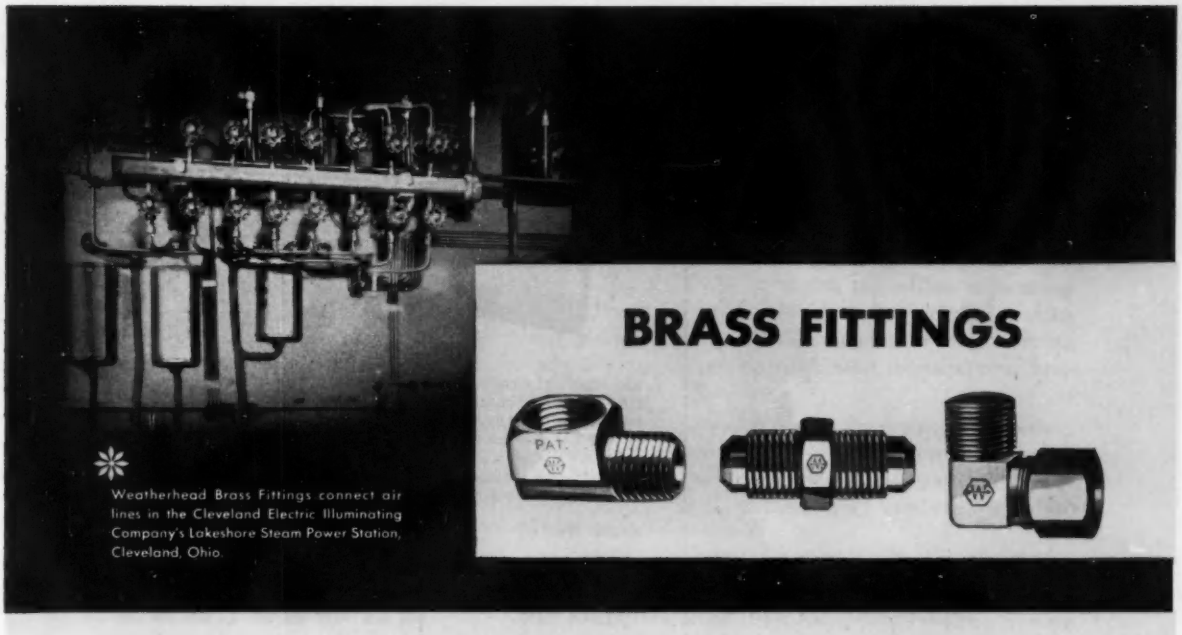

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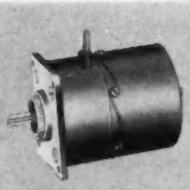
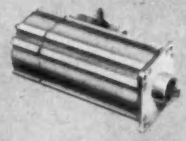
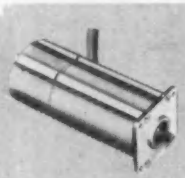


Fast action clutch-brake of unique Lear design utilizing two opposing coils to force clutching and declutching. increases the speed of both operations. Typical application: digital mechanical computor.

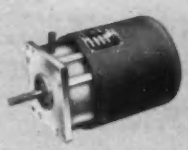
Specially designed Lear motor utilizing offset gear train to allow close tolerance between mounting surface and output shaft. Typical application: aircraft scavenger pump.



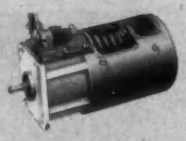
Lear intermittent duty AC motor. Has high torque AC brake capable of stopping both rotor and connected inertia load. Typical application: positioning actuator for jet engine air intake doors.



Lear AC brake motor with exceptional environmental resistance. Non-corrosive materials used throughout, including laminations. Typical application: aileron trim tab actuation.



AC motor of the air-over-totally-enclosed type. Has special mylar high dielectric insulation. Typical application: hydraulic pumps.

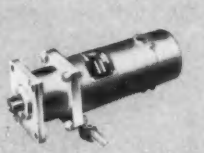


Synchronous AC motor. Has exceptional high starting torque which overcomes starting drag characteristics. Provides optimum low temperature operation. Typical application: radar scanning device.

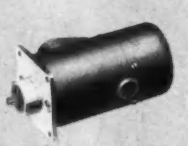
DC intermittent duty motor incorporating Lear Fastop Clutch. Extensively used for heavy duty. Typical application: cowl flap power unit.

Miniature DC motor. Unusual specifications required armature which could be stalled continuously and a field to match 10,000 ohm impedance of vacuum tube amplifier. Typical application: trim tab servo.

Lear DC motor with noise filter designed integrally into special pump base. Totally enclosed and self-ventilated. Typical application: pumps.



Gearhead DC motor. Demonstrates building block flexibility. Gearhead components are available in a variety of gear ratios for all Lear motors. Typical application: guided missile fin actuation.



DC brake motor with quick stopping and high holding torque. Optional thermal protection. Typical application: seat actuator.

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...and all of aircraft quality!

Although Lear's production of electric aircraft motors impresses by its magnitude, the major emphasis is first, last, and always upon ***quality.*** It is doubtful that any other company invests as much engineering time into every motor it builds. An entire, top-calibre engineering department is devoted exclusively to motor design, making Lear exceptionally qualified to handle the more exacting and difficult applications which most manufacturers hesitate to tackle.

Lear's excellent ***facilities*** for the design, engineering, production, and testing of motors are devoted to building *aircraft* motors and aircraft motors alone. Lear motors are designed to meet every applicable military specification.

Lear has accumulated immense ***experience*** in the manufacture of motors of aircraft quality, having built over one million since 1941. All motors used on precision Lear equipment such as electro-mechanical actuators, vertical gyro indicator systems, and F-5 autopilots, are Lear motors, so they *have* to be good.

Lear is an acknowledged leader in the field of motor noise ***filtering.*** Noise filters are engineered into Lear motors at the design stage — not added as an afterthought when the product is finished — thus providing substantial savings in weight and space, and tangible bonuses in performance.

Lear motors achieved early prominence through the use of the Lear "Fastop" clutch, and are now available with a complete line of ***braking*** devices, including both AC and DC brakes of the single-disk and multiple-disk types (which incidentally, are offered as separate components to other manufacturers).

Although all Lear motors are new ***designs,*** an infinite variety of additional models are available through combination of arrangements used in our regular families of motors, of which only a small part are illustrated here. Thus, Lear-quality models can be designed, and are designed, to meet practically any specialized requirement.

If you need any kind of an aircraft electrical motor — and if you want the best — it will pay you to consult Lear. Write, wire, or phone your nearest Lear Sales Office or Lear, Inc., 110 Ionia Avenue, Grand Rapids 2, Michigan.

Gearhead DC motor. Continuous duty, air-over-totally-enclosed type with single stage reduction spur gearing and built-in filter. Typical application: aircraft fuel pump.

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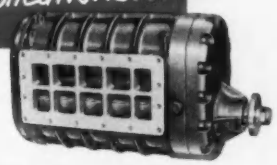

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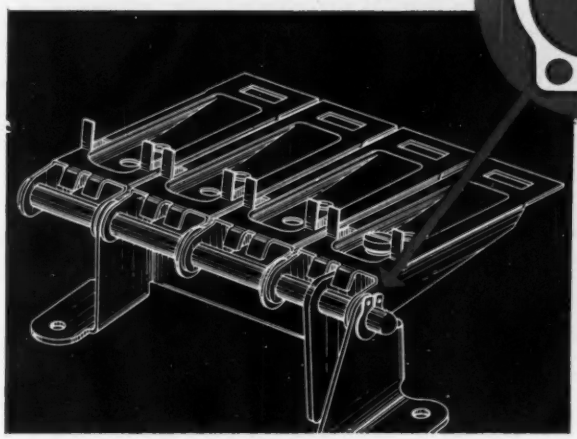

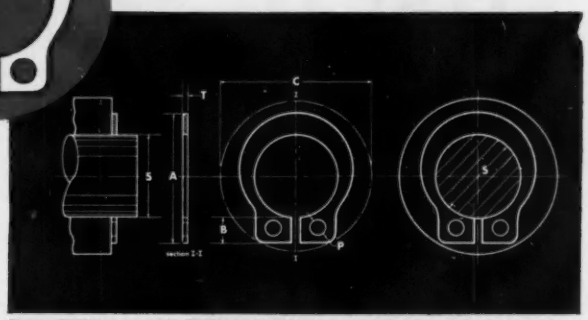

Ring #5555		5555-12	5555-13½	5555-18	5555-25	5555-31	5555-37
SHAFT DIAMETER	Fract. Equiv. S	1/8"	—	3/16"	1/4"	5/16"	3/8"
	Dec. Equiv. S	.125	.136	.187	.250	.312	.375
	TOL.	±.002	±.002	±.002	±.002	±.003	±.003
RING DIMENSIONS	Thickness T	.025	.025	.035	.035	.042	.042
	TOL.	±.0015	±.0015	±.002	±.002	±.002	±.002
	Length A	.268	.285	.364	.437	.553	.626
	Lug B	.078	.078	.097	.097	.141	.141
	Hole P	.042	.042	.042	.042	.078	.078
	Min. Ring Clear C	.33	.34	.44	.50	.67	.73
Approx. Ultim. Thrust Load (Lbs)		20	20	25	35	50	60

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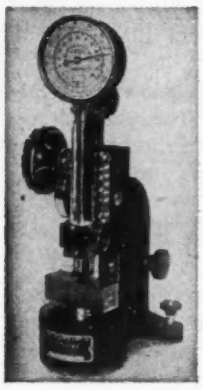

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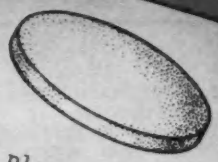

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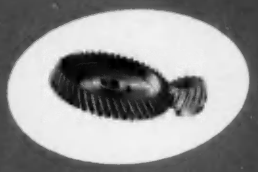

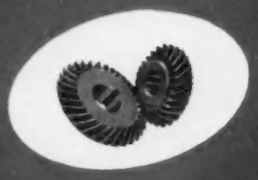

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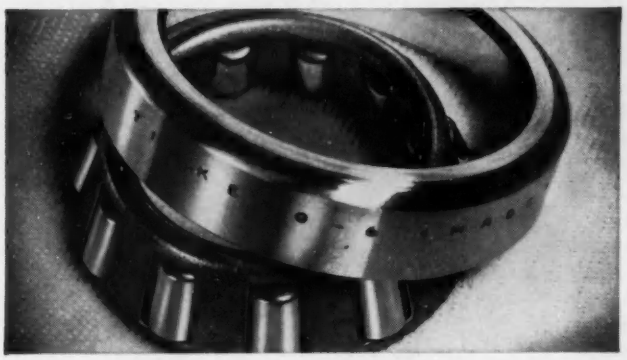

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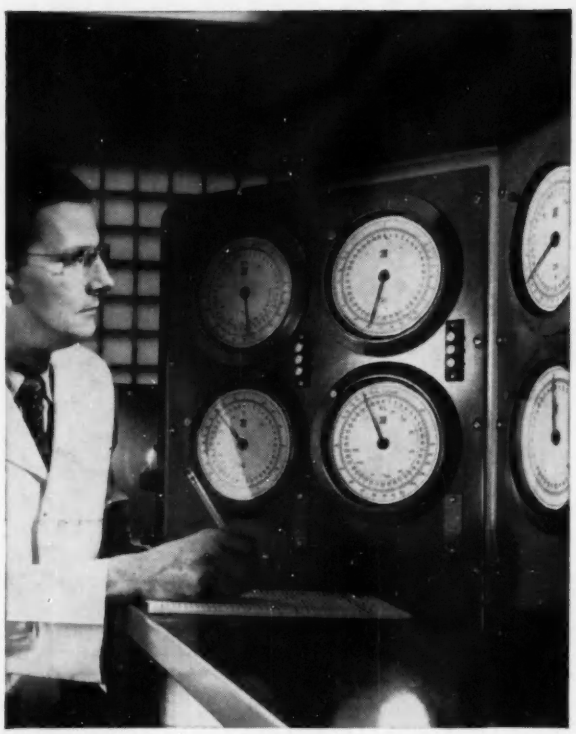

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